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* * *

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UNIFORM MECHANICAL CODE™

1991 Edition

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UNIFORM BUILDING CODE ®

INTERNATIONAL ASSOCIATION OF PLUMBING & MECHANICAL OFFICIALS
IAPMO ®

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5360 SOUTH WORKMAN MILL ROAD
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and

INTERNATIONAL ASSOCIATION OF PLUMBING AND MECHANICAL OFFICIALS
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Preface

THE UNIFORM MECHANICAL CODE™ is designed to provide complete requirements for the installation and maintenance of heating, ventilating, cooling and refrigeration systems. This code is a joint publication of the International Conference of Building Officials (ICBO) and the International Association of Plumbing and Mechanical Officials (IAPMO).

THE UNIFORM MECHANICAL CODE was first published in 1967. Changes to the code are processed each year. This, the 1991 edition, reflects the results of 24 years' experience with the first edition.

THE UNIFORM MECHANICAL CODE is published as a special document designed to be compatible with the Uniform Building Code, 1991 edition.

Anyone may propose amendments to this code. For more information, write to the International Conference of Building Officials as addressed on the facing page. Changes to the code are processed each year and published in supplements in a form permitting ready adoption by local communities. These changes are carefully reviewed in public hearings by professional experts in the field of building construction and fire and life safety.

Vertical lines in the margin indicate a change in the requirements from the 1988 edition except where the entire chapter was revised, or a new chapter was added. Where an entire chapter is changed or new chapter was added, a notation appears at the beginning of that chapter. Vertical lines in the margin that are interrupted by the letter "F" indicate that the provision is maintained under the code change procedures of the Western Fire Chiefs Association. Deletion indicators (➽) are provided in the margin where a paragraph or item in a listing has been deleted if the deletion resulted in a change of requirements.

An analysis of changes between editions is published in pamphlet form by the Conference.

RELATED PUBLICATIONS

Known widely for its Uniform Building Code, the International Conference of Building Officials publishes other related codes as well as textbooks to enable the user to improve his knowledge of code enforcement and the administration of a building inspection program. Publications are continually being added, so inquiries should be directed to Conference headquarters for a list of those available. At the time of this publication, the following publications were available:

Uniform Building Code. Covers the fire, life and structural safety aspects of all buildings and related structures.

Handbook to the Uniform Building Code—An illustrative commentary. A new publication containing a description of the purpose and intent of individual code sections appearing in the 1991 edition of the Building Code. Where appropriate, provides historical background and references other documents for additional information. Also included are numerous drawings and figures clarifying the application and intent of the 1991 code provisions.

Uniform Building Code Standards. Presents in a compact and concise manner national test, material and special design standards referred to in the Uniform Building Code.

Uniform Plumbing Code. Published by the International Association of Plumbing and Mechanical Officials, the Uniform Plumbing Code covers all aspects of plumbing, including requirements for plumbing materials, and IAPMO installation standards. It is endorsed by the Conference as a companion document to ICBO's model codes and is available from either organization.

Uniform Housing Code. Provides complete requirements affecting conservation and rehabilitation of housing. Its regulations are compatible with the Uniform Building Code.

Uniform Code for the Abatement of Dangerous Buildings. Sets forth orderly procedures for remedying dangerous buildings. Follows due process provisions which reflect the latest court decisions in such matters. This code covers all structures and may be used to supplement the Uniform Housing Code and the Uniform Building Code.

Uniform Sign Code. Dedicated to the development of better sign regulation. Its requirements pertain to all signs and sign construction attached to buildings.

Uniform Administrative Code. This code covers administration areas in connection with adoption of the Uniform Building Code, Uniform Mechanical Code and related codes by a jurisdiction. It contains provisions which relate to site preparation, construction, alteration, moving, repair and use and occupancies of buildings or structures and building service equipment including plumbing, electrical and mechanical. The code is compatible with the administrative provisions of all codes published by the Conference.

Uniform Building Security Code. This code establishes minimum standards to make dwelling units resistant to unlawful entry. It regulates swinging doors, sliding doors, windows and hardware in connection with dwelling units of apartment houses or one- and two-family dwellings. The code gives consideration to the concerns of police, fire and building officials in establishing requirements for resistance to burglary which are compatible with fire and life safety.

Uniform Code for Building Conservation. A building conservation guideline presented in code format which will provide a community with the means to preserve their existing buildings while achieving appropriate levels of safety. It is formatted in the same manner as the Uniform Building Code, compatible with other Uniform Codes, and may be adopted as a code or used as a guideline.

Dwelling Construction Under the Uniform Building Code. Designed to acquaint the home builder with basic Building Code requirements relating to dwelling construction. A useful text for apprentice training programs.

Uniform Fire Code. Sets out provisions necessary for fire prevention while achieving uniformity in terms and requirements with other codes published by the Conference. This code is sponsored jointly by the Western Fire Chiefs Association and the International Conference of Building Officials.

Uniform Fire Code Standards. This publication is a companion to the Uniform Fire Code. It contains standards of the American Society for Testing and Materials and of the National Fire Protection Association referenced by the Uniform Fire Code.

U.B.C. Supplements. Between new editions of the codes, changes approved each year are incorporated in the supplements.

Analysis of Revisions. Discusses the changes included in the latest codes published by the Conference as compared to the prior editions.

Uniform Building Code—1927 Edition. A special 60th anniversary printing of the first published Uniform Building Code.

CABO One and Two Family Dwelling Code. This code is jointly sponsored by the International Conference of Building Officials, Building Officials and Code Administrators International, Inc., and Southern Building Code Congress International, Inc. It eliminates conflicts and duplications among the model codes to achieve national uniformity. Covers mechanical and plumbing requirements as well as construction and occupancy.

Application and Commentary CABO One and Two Family Dwelling Code. An interpretive commentary on the CABO One and Two Family Dwelling Code intended to enhance uniformity of interpretation and application of the code nationwide. Developed by the three model code organizations under contract with the Department of Housing and Urban Development (HUD) and in cooperation with the National Association of Home Builders (NAHB).

CABO Model Energy Code. This code sets forth minimum requirements for effective use of energy in the design of new buildings and structures and additions to existing buildings. It is based on ASHRAE Standard 90A-1980 and was originally developed jointly by ICBO, BOCA, SBCCI and the National Conference of States on Building Codes and Standards (NCSBCS) under a contract funded by the U.S. Department of Energy. The code is now maintained by the Council of American Building Officials (CABO) and is adopted by reference in the Uniform Building Code.

Uniform Disaster Mitigation Plan. A plan developed to aid building departments in coping with major disasters such as fires, floods and earthquakes. Defines standard operating procedures for initiating disaster assessment and mitigation and includes samples of records, reports, entry signs, etc.

National Electrical Code. The National Electrical Code is the electrical code for the majority of states, counties and cities in the United States. Researched and published every three years by the National Fire Protection Association, it is an indispensable aid to every electrician, electrical inspector, electrical equipment manufacturer, architect, builder, consulting engineer, contractor, fire marshal, fire chief, building inspector and anyone who must specify or certify electrical installations.

Building Department Administration. An excellent guide for improvement of skills in departmental management and in the enforcement and application of the Building Code and other regulations administered by a building inspection department. Recommended for both undergraduate and advanced study.

Uniform Building Code Application/Interpretation Manual. A manual discussing sections of the Uniform Building Code with a question/answer format, providing a comprehensive analysis of the intent of the code section. Most sections include illustrative examples. The manual is in loose-leaf form so that code interpretations published in *Building Standards* may be inserted.

Plan Review Manual. Provides an understanding of the extent of Building Code provisions and illustrates application to given situations. Covers nonstructural aspects as well as providing an insight into the basic engineering considerations a plan examiner or checker must utilize.

Field Inspection Manual. Designed to improve inspection skills and techniques. A fundamental important text for courses of study at the community college and trade or technical school level.

Building Official Management Manual. This manual addresses the unique nature of code administration and the managerial duties of the building official. A supplementary insert addresses the budgetary and financial aspects of a building department. It is also an ideal resource for those preparing for the management module of the CABO Building Official Certification Examination.

Legal Aspects of Code Administration. A manual developed by the three model code organizations to inform the building official on the legal aspects of the profession. The text is written in a logical sequence with explanation of legal terminology and is designed to serve as a refresher to those preparing to take the legal module of the CABO Building Official Certification Examination.

Illustrated Mechanical Manual. Contains a series of illustrations with explanatory text covering requirements in the Uniform Mechanical Code which respond to graphic treatment. It is highly useful for code application and for training purposes.

Concrete Manual. A publication on concrete to be used for reference or as a text on concrete inspection. Of particular interest to inspectors, it is also useful to concrete technicians and craftsmen who are more concerned with the physical and practical aspects of concrete than the design.

You Can Build It! Sponsored by ICBO in cooperation with the Council of American Building Officials (CABO), this booklet contains information and advice to aid "do-it-yourselfers" with building projects. Provides guidance in necessary procedures such as permit requirements, codes, plans, cost estimation, etc.

Guidelines for Manufactured Housing Installations. A guideline in code form implementing the Uniform Building Code and its companion code documents to regulate the permanent installation of a manufactured home on a privately owned nonrental site. A commentary is included to explain specific provisions, and codes applying to each component part are defined.

Tabulated Fire-Resistive Requirements by Occupancy. Related code requirements are assembled for quick access. The tabulations assemble the limitations in Tables Nos. 5-A, 5-B, 5-C, and 17-A and the provisions of the 01 through 03 sections of the occupancy and type of construction chapters in the Uniform Building Code.

Introduction to the Uniform Building Code Workbook. A student workbook containing a series of exercises designed to compliment the course "Introduction to the Uniform Building Code, BIT-100." Assignments are arranged to provide an overview of the basics of the Uniform Building Code.

Plan Reading and Nonstructural Plan Review Workbook. A series of exercises intended to be a useful tool in understanding the concepts developed in "Plan Reading and Nonstructural Plan Review, BIT-101." The student exercises include assignments on code requirements and plan reading.

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SAMPLE ORDINANCE FOR ADOPTION OF THE UNIFORM MECHANICAL CODE

ORDINANCE NO. _____

An ordinance of the ____(jurisdiction)____ adopting the 1991 edition of the Uniform Mechanical Code, regulating and controlling the design, construction, quality of materials, erection, installation, alteration, repair, location, relocation, replacement, addition to, use or maintenance of heating, ventilating, cooling, refrigeration systems, incinerators, or other miscellaneous heat-producing appliances in the ____(jurisdiction)____; providing for the issuance of permits and collection of fees therefore; repealing Ordinance No. _____ of the ____(jurisdiction)____ and all other ordinances and parts of the ordinances in conflict therewith.

The ____(governing body)____ of the ____(jurisdiction)____ does ordain as follows:

Section 1. That certain documents, three (3) copies of which are on file in the office of the ____(jurisdiction's keeper of records)____ and the ____(jurisdiction)____, being marked and designated as "Uniform Mechanical Code," including Appendix Chapter A (and Appendix Chapter B if specifically adopted) [fill in the applicable Appendix Chapters. (See *Uniform Mechanical Code* Section 103, paragraphs 4, 5 and 6, 1991 edition)] published by the International Conference of Building Officials, be and is hereby adopted as the code of the ____(jurisdiction)____ for regulating the design, construction, quality of materials, erection, installation, alteration, repair, location, relocation, replacement, addition to, use or maintenance of heating, ventilating, cooling, refrigeration systems, incinerators or other miscellaneous heat-producing appliances in the ____(jurisdiction)____ providing for the issuance of permits and collection of fees therefore; and each and all of the regulations, provisions, conditions and terms of such "Uniform Mechanical Code," 1991 edition, published by the International Conference of Building Officials, on file in the office of the ____(jurisdiction)____ are hereby referred to, adopted and made a part hereof as if fully set out in this ordinance.

Section 2. (Incorporate penalties for violations. See Section 204).

Section 3. That Ordinance No. _____ of ____(jurisdiction)____ entitled *(fill in here the complete title of the present mechanical ordinance or ordinances in effect at the present time so that they will be repealed by definite mention)* and all other ordinances or parts of ordinances in conflict herewith are hereby repealed.

Section 4. That if any section, subsection, sentence, clause or phrase of this ordinance is, for any reason, held to be unconstitutional, such decision shall not affect the validity of the remaining portions of this ordinance. The ____(governing body)____ hereby declares that it would have passed this ordinance, and each section, subsection, clause or phrase thereof, irrespective of the fact that any one or more sections, subsections, sentences, clauses and phrases be declared unconstitutional.

Section 5. That the ____(jurisdiction's keeper of records)____ is hereby ordered and directed to cause this ordinance to be published. *(An additional provision may be required to direct the number of times the ordinance is to be published and to* *specify that it is to be in a newspaper in general circulation. Posting may also be required.)*

Section 6. That this ordinance and the rules, regulations, provisions, requirements, orders and matters established and adopted hereby shall take effect and be in full force and effect ____(time period)____ from and after the date of its final passage and adoption.

Part I

ADMINISTRATIVE

Chapter 1

TITLE, SCOPE AND GENERAL

Title

Sec. 101. These regulations shall be known as the "Uniform Mechanical Code," may be cited as such, and will be referred to herein as "this code."

Purpose

Sec. 102. The purpose of this code is to provide minimum standards to safeguard life or limb, health, property and public welfare by regulating and controlling the design, construction, installation, quality of materials, location, operation, and maintenance or use of heating, ventilating, cooling, refrigeration systems, incinerators and other miscellaneous heat-producing appliances within this jurisdiction.

The purpose of this code is not to create or otherwise establish or designate any particular class or group of persons who will or should be especially protected or benefited by the terms of this code.

Scope

Sec. 103. The provisions of this code shall apply to the erection, installation, alteration, repair, relocation, replacement, addition to, use or maintenance of any heating, ventilating, cooling, refrigeration systems, incinerators or other miscellaneous heat-producing appliances within this jurisdiction. Mechanical equipment and systems in detached one- and two-family dwellings shall comply with the requirements of Part IV of the One and Two Family Dwelling Code referenced by Appendix Chapter 12 of the Building Code when such appendix chapter is specifically adopted.

Additions, alterations, repairs and replacement of equipment or systems shall comply with the provisions for new equipment and systems except as otherwise provided in Section 104 of this code.

Where, in any specific case, different sections of this code specify different materials, methods of construction or other requirements, the most restrictive shall govern. Where there is a conflict between a general requirement and a specific requirement, the specific requirement shall be applicable.

The Uniform Mechanical Code Standards and Uniform Building Code Standards contained in Appendix A shall be considered as part of this code.

Appendix B contains recommended practices which shall not apply unless specifically adopted.

Appendix C contains gas-venting tables and a list of recommended standards and is intended to serve only as a guide. The design and testing of equipment regulated by this code shall be subject to the approval of the building official.

Application to Existing Mechanical Systems

Sec. 104. (a) **Additions, Alterations or Repairs.** Additions, alterations or repairs may be made to any mechanical system without requiring the existing mechanical system to comply with all the requirements of this code, provided the addition, alteration or repair conforms to that required for a new mechanical system. Additions, alterations or repairs shall not cause an existing system to become unsafe, create unhealthy or overloaded conditions.

Minor additions, alterations and repairs to existing mechanical systems may be installed in accordance with the law in effect at the time the original installation was made, when approved by the building official.

(b) **Existing Installations.** Mechanical systems lawfully in existence at the time of the adoption of this code may have their use, maintenance or repair continued if the use, maintenance or repair is in accordance with the original design and location and no hazard to life, health or property has been created by such mechanical system.

(c) **Changes in Building Occupancy.** Mechanical systems which are a part of any building or structure undergoing a change in use or occupancy, as defined in the Building Code, shall comply with all requirements of this code which may be applicable to the new use or occupancy.

(d) **Maintenance.** All mechanical systems, materials and appurtenances, both existing and new, and all parts thereof shall be maintained in proper operating condition in accordance with the original design and in a safe and hazard-free condition. All devices or safeguards which are required by this code shall be maintained in conformance with the code edition under which installed. The owner or the owner's designated agent shall be responsible for maintenance of mechanical systems and equipment. To determine compliance with this subsection, the building official may cause a mechanical system or equipment to be reinspected.

(e) **Moved Buildings.** Mechanical systems or equipment which are a part of buildings or structures moved into or within this jurisdiction shall comply with the provisions of this code for new installations.

Alternate Materials and Methods of Construction

Sec. 105. The provisions of this code are not intended to prevent the use of any material or method of construction not specifically prescribed by this code, provided any such alternate has been approved and the use authorized by the building official.

The building official may authorize any alternate, provided the building official finds the proposed design is satisfactory for the intended use and complies with the provisions of this code and that the material, method or work offered is, for the purpose intended, at least equivalent to that prescribed by this code in suitability, strength, effectiveness, fire resistance, durability and safety.

The building official shall require sufficient evidence or proof be submitted to substantiate any claims made regarding the use of alternates. The details of any action granting approval of an alternate shall be recorded and shall be entered in the files of the code enforcement agency.

Modifications

Sec. 106. Whenever there are practical difficulties involved in carrying out the provisions of this code, the building official may grant modifications for individual cases. The building official shall first find that a special individual reason makes the strict letter of this code impractical and the modification is in conformity with the intent and purpose of this code and that such modification does not lessen health, life and fire safety requirements. The details of actions granting modifications shall be recorded and entered in the files of the code enforcement agency.

Tests

Sec. 107. Whenever there is insufficient evidence of compliance with the provisions of this code, or evidence that a material or method does not conform to the requirements of this code, or in order to substantiate claims for alternate materials or methods, the building official may require tests as evidence of compliance to be made at no expense to the jurisdiction.

Test methods shall be as specified in this code or by other recognized test standards. In the absence of recognized and accepted test methods, the building official shall specify the testing procedures.

All tests shall be performed by an approved agency. Reports of tests shall be retained by the building official for the period required for retention of public records.

Chapter 2

ORGANIZATION AND ENFORCEMENT

Powers and Duties of Building Official

Sec. 201. (a) **General.** The building official is hereby authorized and directed to enforce all the provisions of this code. For such purposes the building official shall have the powers of a law enforcement officer.

The building official shall have the power to render interpretations of this code and to adopt and enforce rules and regulations supplemental to this code as may be deemed necessary in order to clarify the application of the provisions of this code. Such interpretations, rules and regulations shall be in conformity with the intent and purpose of this code.

(b) **Deputies.** In accordance with the prescribed procedures and with the approval of the appointing authority, the building official may appoint such number of technical officers and inspectors and other employees as shall be authorized from time to time. The building official may deputize such inspectors or employees as may be necessary to carry out the functions of the code enforcement agency.

(c) **Right of Entry.** When it is necessary to make an inspection to enforce the provisions of this code, or when the building official has reasonable cause to believe that there exists in a building or upon a premises a condition which is contrary to or in violation of this code which makes the building or premises unsafe, dangerous or hazardous, the building official may enter the building or premises at reasonable times to inspect or to perform the duties imposed by this code, provided that if such building or premises be occupied that credentials be presented to the occupant and entry requested. If such building or premises be unoccupied, the building official shall first make a reasonable effort to locate the owner or other person having charge or control of the building or premises and request entry. If entry is refused, the building official shall have recourse to the remedies provided by law to secure entry.

(d) **Stop Orders.** When any work is being done contrary to the provisions of this code, the building official may order the work stopped by notice in writing served on any persons engaged in the doing or causing such work to be done, and such persons shall forthwith stop work until authorized by the building official to proceed with the work.

(e) **Authority to Disconnect Utilities in Emergencies.** The building official or the building official's authorized representative shall have the authority to disconnect fuel-gas utility service, or energy supplies to a building, structure, premises or equipment regulated by this code in case of emergency where necessary to eliminate an immediate hazard to life or property. The building official shall, whenever possible, notify the serving utility, the owner and occupant of the building, structure or premises of the decision to disconnect prior to taking such action, and shall notify such serving utility, owner and occupant of the building, structure or premises in writing of such disconnection immediately thereafter.

(f) **Authority to Condemn Equipment.** When the building official ascertains that any equipment, or portion thereof, regulated by this code has become hazardous to life, health or property, the building official shall order in writing that the equipment either be removed or restored to a safe or sanitary condition, as appropriate. The written notice shall contain a fixed time limit for compliance with such order. Persons shall not use or maintain defective equipment after receiving a notice.

When equipment or an installation is to be disconnected, written notice of the disconnection and causes therefor shall be given within 24 hours to the serving utility, the owner and occupant of the building, structure or premises. When any equipment is maintained in violation of this code, and in violation of a notice issued pursuant to the provisions of this section, the building official shall institute an appropriate action to prevent, restrain, correct or abate the violation.

(g) **Connection after Order to Disconnect.** Persons shall not make connections from an energy, fuel or power supply nor supply energy or fuel to any equipment regulated by this code which has been disconnected or ordered to be disconnected by the building official or the use of which has been ordered to be discontinued by the building official until the building official authorizes the reconnection and use of such equipment.

(h) **Liability.** The building official charged with the enforcement of this code acting in good faith and without malice in the discharge of the duties required by this code or other pertinent law or ordinance shall not thereby be rendered personally liable for damages that may accrue to persons or property as a result of an act or by reason of an act or omission in the discharge of such duties. A suit brought against the building official or employee because of such act or omission performed by the building official or employee in the enforcement of any provision of such codes or other pertinent laws or ordinances implemented through the enforcement of this code or enforced by the code enforcement agency shall be defended by this jurisdiction until final termination of such proceedings, and any judgment resulting therefrom shall be assumed by this jurisdiction.

This code shall not be construed to relieve from or lessen the responsibility of any person owning, operating or controlling any equipment regulated herein for damages to persons or property caused by defects, nor shall the code enforcement agency or its parent jurisdiction be held as assuming any such liability by reason of the inspections authorized by this code or any permits or certificates issued under this code.

(i) **Cooperation of Other Officials and Officers.** The building official may request, and shall receive the assistance and cooperation of other officials of this jurisdiction so far as is required in the discharge of the duties required by this code or other pertinent law or ordinance.

Unsafe Equipment

Sec. 202. Equipment regulated by this code, which is unsafe or which constitutes a fire or health hazard or is otherwise dangerous to human life is, for the purpose of this section, unsafe. Use of equipment regulated by this code constituting a hazard to safety, health or public welfare by reason of inadequate maintenance, dilapidation, obsolescence, fire hazard, disaster, damage or abandonment is, for the purpose of this section, an unsafe use. Unsafe equipment is hereby declared to be a public nuisance and shall be abated by repair, rehabilitation, demolition or removal in accordance with the procedures set forth in the Uniform Code for the Abatement of Dangerous Buildings or such alternate procedure as may be adopted by this jurisdiction. As an alternative, the building official or other employee or official of this jurisdiction as designated by the governing body may institute other appropriate action to prevent, restrain, correct or abate the violation.

Board of Appeals

Sec. 203. (a) **General.** In order to hear and decide appeals of orders, decisions or determinations made by the building official relative to the application and interpretations of this code, there shall be and is hereby created a Board of Appeals consisting of members who are qualified by experience and training to pass upon matters pertaining to mechanical design, construction and maintenance and the public health aspects of mechanical systems and who are not employees of the jurisdiction. The building official shall be an ex officio member and shall act as secretary to said board but shall have no vote upon any matter before the board. The Board of Appeals shall be appointed by the governing body and shall hold office at its pleasure. The board shall adopt rules of procedure for conducting its business and shall render all decisions and findings in writing to the appellant with a duplicate copy to the building official.

(b) **Limitations of Authority.** The Board of Appeals shall have no authority relative to interpretation of the administrative provisions of this code nor shall the board be empowered to waive requirements of this code.

Violations

Sec. 204. It shall be unlawful for a person, firm or corporation to erect, construct, enlarge, alter, repair, move, improve, remove, convert or demolish, equip, use or maintain mechanical systems or equipment or cause or permit the same to be done in violation of this code.

Chapter 3
PERMITS AND INSPECTIONS

Permits

Sec. 301. (a) **Permits Required.** Except as permitted in Subsection (b) of this section, no mechanical system regulated by this code shall be installed, altered, repaired, replaced or remodeled unless a separate mechanical permit for each separate building or structure has first been obtained from the building official.

(b) **Exempt Work.** A mechanical permit shall not be required for the following:

1. A portable heating appliance, portable ventilating equipment, portable cooling unit or portable evaporative cooler.
2. A closed system of steam, hot or chilled water piping within heating or cooling equipment regulated by this code.
3. Replacement of any component part or assembly of an appliance which does not alter its original approval and complies with other applicable requirements of this code.
4. Refrigerating equipment which is part of the equipment for which a permit has been issued pursuant to the requirements of this code.
5. A unit refrigerating system.

Exemption from the permit requirements of this code shall not be deemed to grant authorization for work to be done in violation of the provisions of this code or other laws or ordinances of this jurisdiction.

Application for Permit

Sec. 302. (a) **Application.** To obtain a permit, the applicant shall first file an application therefor in writing on a form furnished by the code enforcement agency for that purpose. Every such application shall:

1. Identify and describe the work to be covered by the permit for which application is made.
2. Describe the land on which the proposed work is to be done by legal description, street address or similar description that will readily identify and definitely locate the proposed building or work.
3. Indicate the use or occupancy for which the proposed work is intended.
4. Be accompanied by plans, diagrams, computations and specifications and other data as required in Subsection (b) of this section.
5. Be signed by the applicant or an authorized agent of the applicant.
6. Give such other data and information as may be required by the building official.

(b) **Plans and Specifications.** Plans, engineering calculations, diagrams and other data shall be submitted in one or more sets with each application for a permit. When such plans are not prepared by an architect or engineer, the building official may require any applicant submitting such plans or other data to demonstrate that state law does not require that the plans be prepared by an architect or engineer. The building official may require plans, computations and specifications to be prepared and designed by an engineer or architect licensed by the state to practice as such even if not required by state law.

> **EXCEPTION:** The building official may waive the submission of plans, calculations or other data if it is found that the nature of the work applied for is such that reviewing of plans is not necessary to obtain compliance with this code.

(c) **Information on Plans and Specifications.** Plans and specifications shall be drawn to scale upon substantial paper or cloth and shall be of sufficient clarity to indicate the location, nature and extent of the work proposed and show in detail that it will conform to the provisions of this code and relevant laws, ordinances, rules and regulations.

Plans for buildings more than two stories in height of other than Groups R, Division 3 and M Occupancies shall indicate how required structural and fire-resistive integrity will be maintained where a penetration will be made for electrical, mechanical, plumbing and communication conduits, pipes and similar systems.

Permit Issuance

Sec. 303. (a) **Issuance.** The application, plans, specifications, computations and other data filed by an applicant for permit shall be reviewed by the building official. Such plans may be reviewed by other departments of this jurisdiction to verify compliance with applicable laws under their jurisdiction. If the building official finds that the work described in an application for a permit and the plans, specifications and other data filed therewith conform to the requirements of this code and other pertinent laws and ordinances and that the fees specified in Section 304 have been paid, the building official shall issue a permit therefor to the applicant.

When issuing a permit where plans are required, the building official shall endorse in writing or stamp the plans and specifications "APPROVED." Such approved plans and specifications shall not be changed, modified or altered without authorization from the building official, and all work regulated by this code shall be done in accordance with the approved plans.

The building official may issue a permit for the construction of a part of a mechanical system before the entire plans and specifications for the whole system have been submitted or approved, provided adequate information and detailed statements have been filed complying with all pertinent requirements of this code. The holder of a partial permit may proceed without assurance that the permit for the entire building, structure or mechanical system will be granted.

(b) **Retention of Plans.** One set of approved plans, specifications and computations shall be retained by the building official until final approval of the work covered therein. One set of approved plans and specifications shall be returned to the applicant, and said set shall be kept on the site of the building or work at all times during which the work authorized thereby is in progress.

(c) **Validity of Permit.** The issuance of a permit or approval of plans, specifications and computations shall not be construed to be a permit for, or an approval of, any violation of any of the provisions of this code or of other ordinance of the jurisdiction. Permits presuming to give authority to violate or cancel the provisions of this code or of other ordinances of the jurisdiction shall not be valid.

The issuance of a permit based upon plans, specifications, computations and other data shall not prevent the building official from thereafter requiring the correction of errors in said plans, specifications, and other data or from preventing building operations being carried on thereunder when in violation of this code or of other ordinances of this jurisdiction.

(d) **Expiration.** Every permit issued by the building official under the provisions of this code shall expire by limitation and become null and void if the work authorized by such permit is not commenced within 180 days from the date of such permit, or if the work authorized by such permit is suspended or abandoned at any time after the work is commenced for a period of 180 days. Before such work can be recommenced, a new permit shall be first obtained so to do, and the fee therefor shall be one half the amount required for a new permit for such work, provided no changes have been made or will be made in the original plans and specifications for such work and provided further that such suspension or abandonment has not exceeded one year. No permit shall be extended more than once. In order to renew action on a permit after expiration, the permittee shall pay a new full permit fee.

A permittee holding an unexpired permit may apply for an extension of the time within which work may be commenced under that permit when the permittee is unable to commence work within the time required by this section for good and satisfactory reasons. The building official may extend the time for action by the permittee for a period not exceeding 180 days upon written request by the permittee showing that circumstances beyond the control of the permittee have prevented action from being taken.

(e) **Suspension or Revocation.** The building official may, in writing, suspend or revoke a permit issued under the provisions of this code whenever the permit is issued in error or on the basis of incorrect information supplied or in violation of other ordinance or regulation of the jurisdiction.

Fees

Sec. 304. (a) **General.** Fees shall be assessed in accordance with the provisions of this section or shall be as set forth in the fee schedule adopted by this jurisdiction.

(b) **Permit Fees.** The fee for each permit shall be as set forth in Table No. 3-A.

(c) **Plan Review Fees.** When a plan or other data are required to be submitted by Section 302 (b), a plan review fee shall be paid at the time of submitting plans and specifications for review. The plan review fees for mechanical work shall be equal to 25 percent of the total permit fee as set forth in Table No. 3-A.

The plan review fees specified in this subsection are separate fees from the permit fees specified in Section 304 (a) and are in addition to the permit fees.

When plans are incomplete or changed so as to require additional plan review, an additional plan review fee shall be charged at the rate shown in Table No. 3-A.

(d) **Expiration of Plan Review.** Applications for which no permit is issued within 180 days following the date of application shall expire by limitation, and plans and other data submitted for review may thereafter be returned to the applicant or destroyed by the building official. The building official may extend the time for action by the applicant for a period not exceeding 180 days upon request by the applicant showing that circumstances beyond the control of the applicant have prevented action from being taken. No application shall be extended more than once. In order to renew action on an application after expiration, the applicant shall resubmit plans and pay a new plan review fee.

(e) **Investigation Fees: Work without a Permit.** 1. **Investigation.** Whenever any work for which a permit is required by this code has been commenced without first obtaining said permit, a special investigation shall be made before a permit may be issued for such work.

2. **Fee.** An investigation fee, in addition to the permit fee, shall be collected whether or not a permit is then or subsequently issued. The investigation fee shall be equal to the amount of the permit fee that would be required by this code if a permit were to be issued. The payment of such investigation fee shall not exempt any person from compliance with all other provisions of this code nor from any penalty prescribed by law.

(f) **Fee Refunds.** 1. The building official may authorize the refunding of any fee paid hereunder which was erroneously paid or collected.

2. The building official may authorize refunding of not more than 80 percent of the permit fee paid when no work has been done under a permit issued in accordance with this code.

3. The building official may authorize refunding of not more than 80 percent of the plan review fee paid when an application for a permit for which a plan review fee has been paid is withdrawn or canceled before any plan review effort has been expended.

The building official shall not authorize refunding of any fee paid except upon written application filed by the original permittee not later than 180 days after the date of fee payment.

Inspections

Sec. 305. (a) **General.** Mechanical systems for which a permit is required by this code shall be subject to inspection by the building official and such mechanical systems shall remain accessible and exposed for inspection purposes until approved by the building official.

It shall be the duty of the permit applicant to cause the mechanical systems to remain accessible and exposed for inspection purposes. Neither the building official nor the jurisdiction shall be liable for expense entailed in the removal or replacement of any material required to permit inspection. When the installation of a mechanical system is complete, an additional and final inspection shall be made. Mechanical systems regulated by this code shall not be connected to the energy fuel-supply lines until authorized by the building official.

Approval as a result of an inspection shall not be construed to be an approval of a violation of the provisions of this code or of other ordinances of the jurisdiction. Inspections presuming to give authority to violate or cancel the provisions of this code or of other ordinances of the jurisdiction shall not be valid.

(b) **Operation of Mechanical Equipment.** The requirements of this section shall not be considered to prohibit the operation of mechanical systems installed to replace existing equipment or fixtures serving an occupied portion of the building in the event a request for inspection of such equipment or fixture has been filed with the building official not more than 48 hours after such replacement work is completed, and before any portion of such mechanical system is concealed by any permanent portion of the building.

(c) **Testing of Equipment.** Refrigeration equipment regulated by this code shall be tested and approved as required by Section 1520 of this code.

Where applicable (see Section 103), steam and hot-water boilers and piping shall be tested and approved as required by Sections 2123 and 2127 of Appendix B of this code.

Where applicable (see Section 103), fuel-gas piping shall be tested and approved as required by Section 2206 of Appendix B of this code.

(d) **Inspection Requests.** It shall be the duty of the person doing the work authorized by a permit to notify the building official that such work is ready for inspection. The building official may require that every request for inspection be filed at least one working day before such inspection is desired. Such request may be in writing or by telephone at the option of the building official.

It shall be the duty of the person requesting inspections required by this code to provide access to and means for inspection of such work.

(e) **Other Inspections.** In addition to the called inspections required by this code, the building official may make or require other inspections of mechanical work to ascertain compliance with the provisions of this code and other laws which are enforced by the code enforcement agency.

(f) **Reinspections.** A reinspection fee may be assessed for each inspection or reinspection when such portion of work for which inspection is requested is not complete or when required corrections have not been made.

This provision is not to be interpreted as requiring reinspection fees the first time a job is rejected for failure to comply with the requirements of this code, but as controlling the practice of calling for inspections before the job is ready for inspection or reinspection.

Reinspection fees may be assessed, when the approved plans are not readily available to the inspector, for failure to provide access on the date for which inspection is requested or for deviating from plans requiring the approval of the building official.

To obtain reinspection, the applicant shall file an application therefor in writing upon a form furnished for that purpose and pay the reinspection fee in accordance with Table No. 3-A or as set forth in the fee schedule adopted by the jurisdiction.

In instances where reinspection fees have been assessed, no additional inspection of the work will be performed until the required fees have been paid.

Connection Approval

Sec. 306. (a) **Energy Connections.** No person shall make connections from a source of energy fuel to any mechanical system or equipment regulated by this code and for which a permit is required until approved by the building official.

(b) **Temporary Connections.** The building official may authorize temporary connection of the mechanical equipment to the source of energy or fuel for the purpose of testing the equipment, or for use under a temporary certificate of occupancy.

TABLE NO. 3-A—MECHANICAL PERMIT FEES

Permit Issuance		
1.	For the issuance of each permit	$15.00
2.	For issuing each supplemental permit	4.50
Unit Fee Schedule		
1.	For the installation or relocation of each forced-air or gravity-type furnace or burner, including ducts and vents attached to such appliance, up to and including 100,000 Btu/h	9.00
2.	For the installation or relocation of each forced-air or gravity-type furnace or burner, including ducts and vents attached to such appliance over 100,000 Btu/h	11.00
3.	For the installation or relocation of each floor furnace, including vent	9.00
4.	For the installation or relocation of each suspended heater, recessed wall heater or floor-mounted unit heater	9.00
5.	For the installation, relocation or replacement of each appliance vent installed and not included in an appliance permit	4.50
6.	For the repair of, alteration of, or addition to each heating appliance, refrigeration unit, cooling unit, absorption unit, or each heating, cooling, absorption, or evaporative cooling system, including installation of controls regulated by this code	9.00
7.	For the installation or relocation of each boiler or compressor to and including three horsepower, or each absorption system to and including 100,000 Btu/h	9.00
8.	For the installation or relocation of each boiler or compressor over three horsepower to and including 15 horsepower, or each absorption system over 100,000 Btu/h and including 500,000 Btu/h	16.50
9.	For the installation or relocation of each boiler or compressor over 15 horsepower to and including 30 horsepower, or each absorption system over 500,000 Btu/h to and including 1,000,000 Btu/h	22.50
10.	For the installation or relocation of each boiler or compressor over 30 horsepower to and including 50 horsepower, or for each absorption system over 1,000,000 Btu/h to and including 1,750,000 Btu/h	33.50
11.	For the installation or relocation of each boiler or refrigeration compressor over 50 horsepower, or each absorption system over 1,750,000 Btu/h	56.00
12.	For each air-handling unit to and including 10,000 cubic feet per minute, including ducts attached thereto **Note:** This fee shall not apply to an air-handling unit which is a portion of a factory-assembled appliance, cooling unit, evaporative cooler or absorption unit for which a permit is required elsewhere in this code.	6.50
13.	For each air-handling unit over 10,000 cfm	11.00
14.	For each evaporative cooler other than portable type	6.50
15.	For each ventilation fan connected to a single duct	4.50

TABLE NO. 3-A—MECHANICAL PERMIT FEES—(Continued)

16. For each ventilation system which is not a portion of any heating or air-conditioning system authorized by a permit 6.50
17. For the installation of each hood which is served by mechanical exhaust, including the ducts for such hood 6.50
18. For the installation or relocation of each domestic-type incinerator 11.00
19. For the installation or relocation of each commercial or industrial-type incinerator 45.00
20. For each appliance or piece of equipment regulated by this code but not classed in other appliance categories, or for which no other fee is listed in this code 6.50
21. When Chapter 22 is applicable (see Section 103), permit fees for fuel-gas piping shall be as follows:
    For each gas-piping system of one to four outlets 3.00
    For each gas-piping system of five or more outlets, per outlet 0.75
22. When Chapter 24 is applicable (see Section 103), permit fees for process piping shall be as follows:
    For each hazardous process piping system (HPP) of one to four outlets 5.00
    For each piping system of five or more outlets, per outlet 1.00
    For each nonhazardous process piping system (NPP) of one to four outlets . 2.00
    For each piping system of five or more outlets, per outlet 0.50

Other Inspections and Fees:

1. Inspections outside of normal business hours . . . . $30.00 per hour* (minimum charge—two hours)
2. Reinspection fees assessed under provisions of Section 305 (g) . . . . $30.00 per hour*
3. Inspections for which no fee is specifically indicated . . . .$30.00 per hour* (minimum charge—one-half hour)
4. Additional plan review required by changes, additions or revisions to approved plans . . . . $30.00 per hour* (minimum charge—one-half hour)

*Or the total hourly cost to the jurisdiction, whichever is the greatest. This cost shall include supervision, overhead, equipment, hourly wages and fringe benefits of the employees involved.

Part II

DEFINITIONS AND ABBREVIATIONS

Chapter 4

DEFINITIONS AND ABBREVIATIONS

General

Sec. 401. For the purpose of this code, certain abbreviations, terms, phrases, words and their derivatives shall be construed as specified in this chapter. Words used in the singular include the plural and the plural the singular. Words used in the masculine gender include the feminine, and the feminine the masculine.

Accepted Meanings

Sec. 402. Except as defined in this chapter or elsewhere in this code, the interpretation of words used in this code shall be in accordance with the meanings defined in the Building Code and *Webster's Third New International Dictionary of the English Language, Unabridged,* copyright 1986.

A

Sec. 403. ABSORPTION UNIT is an absorption refrigerating system which has been factory assembled and tested prior to its installation.

ACCESSIBLE is having access to but which first may require the removal of an access panel, door or similar obstruction covering the item described.

ACCESSIBLE, READILY, means capable of being reached safely and quickly for operation, repair or inspection without requiring those to whom ready access is requisite to climb over or remove obstacles, or to resort to the use of portable access equipment.

AIR, COMBUSTION. See **COMBUSTION AIR,** Section 405.

AIR, EXHAUST, is air being removed from any space or piece of equipment and conveyed directly to the atmosphere by means of openings or ducts.

AIR-HANDLING UNIT is a blower or fan used for the purpose of distributing supply air to a room, space or area.

AIR, MAKEUP, is air which is provided to replace air being exhausted.

AIR, OUTSIDE, is air from outside the building intentionally conveyed by openings or ducts to rooms or to conditioning equipment.

AIR, RETURN, is air from the conditioned area that is returned to the conditioning equipment for reconditioning.

AIR, SUPPLY, is air being conveyed to a conditioned area through ducts or plenums from a heat exchanger of a heating, cooling, absorption or evaporative cooling system.

APPLIANCE is a device which utilizes fuel or other forms of energy to produce light, heat, power, refrigeration or air conditioning. This definition also shall include a vented decorative appliance.

APPROVED, as to materials, equipment and method of construction, refers to approval by the building official as the result of investigation and tests by the building official, or by reason of accepted principles or tests by national authorities, technical or scientific organizations.

APPROVED AGENCY is an established and recognized agency regularly engaged in conducting tests or furnishing inspection services, when such agency has been approved by the building official.

ASSEMBLY BUILDING is a building or a portion of a building used for the gathering together of 50 or more persons for such purposes as deliberation, education, instruction, worship, entertainment, amusement, drinking or dining or awaiting transportation.

B

Sec. 404. BOILER, HIGH PRESSURE, is a boiler furnishing steam at pressures in excess of 15 pounds per square inch or hot water at temperatures in excess of 250°F. or at pressures in excess of 160 pounds per square inch.

BOILER ROOM is any room containing a steam or hot-water boiler.

BRAZED JOINT is any joint obtained by joining of metal parts with alloys which melt at temperatures higher than 800°F. but lower than the melting temperature of the parts to be joined.

BREECHING is a metal connector for medium- and high-heat appliances.

BRINE is any liquid used for the transmission of heat without a change in its state, having no flash point or a flash point above 150°F., as determined by the requirements of U.F.C. Standard No. 9-2.

Btu/h is the listed maximum capacity of any appliance, absorption unit or burner expressed in British thermal units input per hour, unless otherwise noted.

BUILDING CODE is the Uniform Building Code promulgated by the International Conference of Building Officials, as adopted by this jurisdiction.

BUILDING OFFICIAL is the officer charged with the administration and enforcement of this code, or a regularly authorized deputy.

C

Sec. 405. CENTRAL HEATING PLANT or **HEATING PLANT** is environmental heating equipment installed in a manner to supply heat by means of ducts or pipes to areas other than the room or space in which the equipment is located.

CHIMNEY is a vertical shaft enclosing one or more flues for conveying flue gases to the outside atmosphere.

Factory-built Chimney is a listed chimney.

Masonry Chimney is a chimney of solid masonry units, bricks, stones, listed masonry units or reinforced concrete, lined with suitable flue liners.

Metal Chimney is a chimney constructed of metal with a minimum thickness not less than 0.127-inch (No. 10 manufacturer's standard gage) steel sheet.

CHIMNEY CLASSIFICATIONS:

Chimney, Residential Appliance-type, is a factory-built or masonry chimney suitable for removing products of combustion from residential-type appliances producing combustion gases not in excess of 1,000°F., measured at the appliance flue outlet. Factory-built Type HT chimneys have high-temperature thermal shock resistance.

Chimney, Low-heat Appliance-type, is a factory-built, masonry or metal chimney suitable for removing the products of combustion from fuel-burning low-heat appliances producing combustion gases not in excess of 1000°F. under normal operating conditions but capable of producing combustion gases of 1400° F. during intermittent forced firing for periods up to one hour. All temperatures are measured at the appliance flue outlet.

Chimney, Medium-heat Appliance-type, is a factory-built, masonry or metal chimney suitable for removing the products of combustion from fuel-burning medium-heat appliances producing combustion gases not in excess of 2000°F. measured at the appliance flue outlet.

Chimney, High-heat Appliance-type, is a factory-built, masonry or metal chimney suitable for removing the products of combustion from fuel-burning high-heat appliances producing combustion gases in excess of 2000°F. measured at the appliance flue outlet.

CHIMNEY CONNECTOR is the pipe which connects a fuel-burning appliance to a chimney.

CLOSED COMBUSTION SOLID-FUEL-BURNING APPLIANCE is a heat-producing appliance that employs a combustion chamber that has no openings other than the flue collar, fuel charging door and adjustable openings provided to control the amount of combustion air that enters the combustion chamber.

CLOSET. See **CONFINED SPACE.**

COMBUSTION AIR is the total amount of air provided to the space which contains fuel-burning equipment; it includes air for fuel combustion, for draft hood dilution and for ventilation of the equipment enclosure.

COMPANION OR BLOCK VALVES are pairs of mating stop valves, valving off sections of systems and arranged so that these sections may be joined before opening these valves or separated after closing them.

COMPRESSOR is a specific machine, with or without accessories, for compressing a given refrigerant vapor.

CONDENSER is a vessel or arrangement of piping or tubing in which vaporized refrigerant is liquefied by the removal of heat.

CONDENSING APPLIANCE is an appliance which condenses part of the water vapor generated by the burning of hydrogen in fuels.

CONDENSING UNIT is a specific refrigerating machine combination for a given refrigerant, consisting of one or more power-driven compressors, condensers, liquid receivers (when required) and the regularly furnished accessories.

CONDITIONED SPACE is an area, room or space normally occupied and being heated or cooled for human habitation by any equipment.

CONFINED SPACE is a room or space having a volume less than 50 cubic feet per 1000 Btu/h of the aggregate input rating of all fuel-burning appliances installed in that space.

COOLING is air cooling to 50°F. or above.

COOLING SYSTEM is all of that equipment intended or installed for the purpose of cooling air by mechanical means and discharging such air into any room or space. This definition shall not include any evaporative cooler.

COOLING UNIT is a self-contained refrigerating system which has been factory assembled and tested, installed with or without conditioned air ducts and without connecting any refrigerant-containing parts. This definition shall not include a portable cooling unit or an absorption unit.

D

Sec. 406. DAMPERS shall be defined as follows:

Fire Damper is an automatic-closing metal assembly of one or more louvers, blades, slats or vanes complying with U.B.C. Standard No. 43-7.

Smoke Damper is a damper arranged to seal off air flow automatically through a part of an air-duct system so as to restrict the passage of smoke.

Volume Damper is any device which when installed will restrict, retard or direct the flow of air in any duct, or the products of combustion in any heat-producing equipment, its vent connector, vent or chimney therefrom.

DESIGN PRESSURE is the maximum allowable pressure for which a specific part of a system is designed.

DIRECT GAS-FIRED MAKEUP AIR HEATER is a heater in which all the products of combustion generated by the gas-burning device are released into the outside airstream being heated.

DIRECT VENT APPLIANCES are appliances which are constructed and installed so that all air for combustion is derived from the outside atmosphere and all flue gases are discharged to the outside atmosphere.

DISTRICT HEATING PLANT is a power boiler plant designed to distribute hot water or steam to users located off the premises.

DRAFT HOOD is a device built into an appliance or made a part of the vent connector from an appliance, which is designed to:

1. Assure the ready escape of the flue gases in the event of no draft, back draft or stoppage beyond the draft hood.
2. Prevent a back draft from entering the appliance.
3. Neutralize the effect of stack action of the chimney or gas vent upon the operation of the appliance.

DUCT is any tube or conduit for transmission of air. This definition shall not include:

1. A vent, a vent connector or a chimney connector.
2. Any tube or conduit wherein the pressure of the air exceeds 1 pound per square inch.
3. The air passages of listed self-contained systems.

DUCT FURNACE is a warm-air furnace normally installed in an air-distribution duct to supply warm air for heating. This definition shall apply only to a warm-air heating appliance which depends for air circulation on a blower not furnished as part of the furnace.

DUCT SYSTEMS are all ducts, duct fittings, plenums and fans assembled to form a continuous passageway for the distribution of air.

DWELLING is a building or portion thereof which contains not more than two dwelling units.

DWELLING UNIT is a building or portion thereof which contains living facilities, including provisions for sleeping, eating, cooking and sanitation, as required by this code, for not more than one family.

E

Sec. 407. ELECTRIC HEATING APPLIANCE is a device which produces heat energy to create a warm environment by the application of electric power to resistance elements, refrigerant compressors or dissimilar material junctions.

ELECTRICAL CODE is the National Electrical Code promulgated by the National Fire Protection Association, as adopted by this jurisdiction.

EQUIPMENT is a general term including materials, fittings, devices, appliances and apparatus used as part of or in connection with installations regulated by this code.

EVAPORATIVE COOLER is a device used for reducing the sensible heat of air for cooling by the process of evaporation of water into an airstream.

EVAPORATIVE COOLING SYSTEM is all of that equipment intended or installed for the purpose of environmental cooling by an evaporative cooler from which the conditioned air is distributed through ducts or plenums to the conditioned area.

EVAPORATOR is that part of a refrigerating system in which liquid refrigerant is vaporized to produce refrigeration.

F

Sec. 408. FIRE CODE is the Uniform Fire Code promulgated jointly by the Western Fire Chiefs Association and the International Conference of Building Officials, as adopted by this jurisdiction.

FIREPLACE STOVE is a chimney-connected, solid-fuel-burning stove (appliance) having part of its fire chamber open to the room.

FIRE-RESISTIVE CONSTRUCTION is construction complying with the requirements of the Building Code for the time period specified.

FLOOR FURNACE is a completely self-contained furnace suspended from the floor of the space being heated, taking air for combustion from outside such space and with means for observing flames and lighting the appliance from such space.

FORCED-AIR-TYPE CENTRAL FURNACE is a central furnace equipped with a fan or blower which provides the primary means for circulation of air.

Horizontal-type Central Furnace is a furnace designed for low headroom installations with air flow through the appliance in a horizontal path.

Upflow-type Central Furnace is a furnace designed with air flow essentially in a vertical path, discharging air at or near the top of the furnace.

Downflow-type Central Furnace is a furnace designed with air flow essentially in a vertical path, discharging air at or near the bottom of the furnace.

Enclosed Furnace is a specific heating or heating and ventilating furnace incorporating an integral total enclosure and using only outside air for combustion.

FUSIBLE PLUG is a device arranged to relieve the pressure in a container by operation of a fusible member at a predetermined temperature.

G

Sec. 409. GALVANIZED STEEL is any steel conforming to the requirements of U.M.C. Standard No. 4-2.

GENERATOR is a device equipped with a means of heating used in an absorption system to drive refrigerant out of solution.

GRAVITY HEATING SYSTEM is any heating system consisting of a gravity-type warm-air furnace together with all air ducts or pipes and accessory apparatus installed in connection therewith.

GRAVITY-TYPE WARM-AIR FURNACE is a warm-air furnace depending primarily on circulation of air through the furnace by gravity.

This definition also shall include any furnace approved with a booster-type fan which does not materially restrict free circulation of air through the furnace when the fan is not in operation.

H

Sec. 410. HAZARDOUS LOCATION is any area or space where combustible dust, ignitible fibers or flammable, volatile liquids, gases, vapors or mixtures are or may be present in the air in quantities sufficient to produce explosive or ignitible mixtures.

HEATING DEGREE DAY is a unit, based upon temperature difference and time, used in estimating fuel consumption and specifying nominal annual heating load of a building. For any one day when the mean temperature is less than 65°F., there exist as many degree days as there are Fahrenheit degrees difference in temperature between mean temperature for the day and 65°F.

HEATING EQUIPMENT. Includes all warm-air furnaces, warm-air heaters, combustion products vents, heating air-distribution ducts and fans, all steam and hot-water piping together with all control devices and accessories installed as part of, or in connection with, any environmental heating system or appliance regulated by this code.

HEATING SYSTEM is a warm-air heating plant consisting of a heat exchanger enclosed in a casing, from which the heated air is distributed through ducts to various rooms and areas. A heating system includes the outside-air, return-air and supply-air system and all accessory apparatus and equipment installed in connection therewith.

HEAT PUMP is an appliance having heating or heating-cooling capability and which uses refrigerants to extract heat from air, liquid or earth sources.

HIGH SIDE is a portion of a refrigerating system under condenser pressure.

HOOD is an air-intake device connected to a mechanical exhaust system for collecting vapors, fumes, smoke, dust, steam, heat or odors from, at or near the equipment, place or area where generated, produced or released.

I

Sec. 411. INDUSTRIAL HEATING EQUIPMENT is an appliance, device or equipment used, or intended to be used, in an industrial, manufacturing or commercial occupancy for applying heat to any material being processed, but shall not include water heaters, boilers or portable equipment used by artisans in pursuit of a trade.

INSANITARY LOCATION is an area, space or room where the air is unfit or undesirable for circulation to occupied parts of a building.

J

Sec. 412. No definitions.

K

Sec. 413. No definitions.

L

Sec. 414. LINE CONTACT INSTALLATION is where a furnace is installed so that building joists, studs or framing is contacted by the furnace jacket upon the lines formed by the intersection of the jacket sides with the top surface.

LIQUEFIED PETROLEUM GAS, or **LPG (LP Gas)** shall mean and include a material composed predominantly of any of the following hydrocarbons or mixtures of them: propane, propylene, butanes (normal butane or isobutane) and butylenes.

When reference is made to liquefied petroleum gas in this code, it shall refer to liquefied petroleum gases in either the liquid or gaseous state.

LIQUID RECEIVER is a vessel permanently connected to a system by inlet and outlet pipes for storage of a liquid refrigerant.

LISTED and **LISTING** are terms referring to equipment and materials which are shown in a list published by an approved testing agency, qualified and equipped for experimental testing and maintaining an adequate periodic inspection of current productions and which listing states that the material or equipment complies with accepted national standards which are approved, or standards which have been evaluated for conformity with approved standards.

LOW-PRESURE HOT-WATER-HEATING BOILER is a boiler furnishing hot water at pressures not exceeding 160 pounds per square inch and at temperatures not exceeding 250°F.

LOW-PRESSURE STEAM HEATING BOILER is a boiler furnishing steam at pressures not exceeding 15 pounds per square inch.

LOW SIDE refers to the parts of a refrigeration system under evaporator pressure.

M

Sec. 415. MANUFACTURER'S INSTALLATION INSTRUCTIONS are printed instructions included with equipment as part of the conditions of listing.

MECHANICAL JOINT is a joint obtained by the joining of metal parts through a positive-holding mechanical construction.

N

Sec. 416. NONCOMBUSTIBLE, as applied to building construction material, means a material which in the form in which it is used is either one of the following:

1. Material of which no part will ignite and burn when subjected to fire. Any material conforming to U.B.C. Standard No. 4-1 shall be considered noncombustible within the meaning of this section.

2. Material having a structural base of noncombustible material as defined in Item No. 1 above, with a surfacing material not over 1/8 inch thick which has a flame-spread index not higher than 50.

"Noncombustible" does not apply to surface finish materials. Material required to be noncombustible for reduced clearances to flues, heating appliances or other sources of high temperature shall refer to material conforming to Item No. 1. No material shall be classed as noncombustible which is subject to increase in combustibility or flame-spread index beyond the limits herein established, through the effects of age, moisture or other atmospheric condition.

Flame-spread index as used herein refers to results obtained according to tests conducted as specified in U.B.C. Standard No. 42-1.

O

Sec. 417. OCCUPANCY is the purpose for which a building or part thereof is used or intended to be used.

OCCUPANCY CLASSIFICATION. For the purpose of this code, certain occupancies are defined as follows:

Group A Occupancies:

Division 1.1. Any assembly building or portion of a building with a stage and an occupant load of 1,000 or more.

Divison 1.2. Health-care centers for ambulatory patients receiving outpatient medical care which may render the patient incapable of unassisted self-preservation. (Each tenant space accommodating more than five such patients.)

Division 2. Any building or portion of a building having an assembly room with an occupant load of less than 1,000 and a legitimate stage.

Division 2.1. Any building or portion of a building having an assembly room with an occupant load of 300 or more without a legitimate stage, including such buildings used for educational purposes and not classed as a Group E or Group B, Division 2 Occupancy.

Division 3. Any building or portion of a building having an assembly room with an occupant load of less than 300 without a legitimate stage, including such buildings used for educational purposes and not classed as a Group E or Group B, Division 2 Occupancy.

Division 4. Stadiums, reviewing stands and amusement park structures not included within Group A Occupancies.

Group B Occupancies:

Division 1. Repair garages where work is limited to exchange of parts and maintenance requiring no open flame, welding or the use of Class I, II or III-A liquids, motor vehicle fuel-dispensing stations and parking garages not classified as Group B, Division 3 open parking garages or Group M, Division 1 private garages.

Division 2. Drinking and dining establishments having an occupant load of less than 50, wholesale and retail stores, office buildings, printing plants, police and fire stations, factories and workshops using materials not highly flammable or combustible, storage and sales rooms for combustible goods, paint stores without bulk handling.

Buildings or portions of buildings having rooms used for educational purposes beyond the 12th grade with less than 50 occupants in any room.

Division 3. Aircraft hangars where no repair work is done except exchange of parts and maintenance requiring no open flame, welding or the use of Class I or II flammable liquids.

Open parking garages.

Helistops.

Division 4. Ice plants, power plants, pumping plants, cold storage and creameries.

Factories and workshops using noncombustible and nonexplosive materials.

Storage and sales rooms containing only noncombustible and nonexplosive materials that are not packaged or crated in or supported by combustible material.

Group E Occupancies:

Division 1. Any building used for educational purposes through the 12th grade by 50 or more persons for more than 12 hours per week or four hours in any one day.

Division 2. Any building used for educational purposes through the 12th grade by less than 50 persons for more than 12 hours per week or four hours in any one day.

Division 3. Any building or portion thereof used for day-care purposes for more than six persons.

Group H Occupancies:

General. For definitions, identification and control of hazardous materials, display of nonflammable solid and nonflammable or noncombustible liquid hazardous materials in Group B, Division 2 Occupancies, see the Fire Code. For application and use of control areas, see Footnote No.1 of Tables Nos. 9-A and 9-B.

Division 1. Occupancies with a quantity of material in the building in excess of those listed in Table No. 9-A which present a high explosion hazard, including but not limited to:

1. Explosives, blasting agents, fireworks and black powder.

   EXCEPTION: Storage and the use of pyrotechnic special effect materials in motion picture, television, theatrical and group entertainment production when under permit as required in the Fire Code. The time period for storage shall not exceed 90 days.

2. Unclassified detonatable organic peroxides.
3. Class 4 oxidizers.
4. Class 4 or Class 3 detonatable unstable (reactive) materials.

Division 2. Occupancies with a quantity of material in the building in excess of those listed in Table No. 9-A which present a moderate explosion hazard or a hazard from accelerated burning, including but not limited to:

1. Class I organic peroxides.
2. Class 3 nondetonatable unstable (reactive) materials.
3. Pyrophoric gases.
4. Flammable or oxidizing gases.
5. Class I, II or III-A flammable or combustible liquids which are used in normally open containers or systems or in closed containers pressurized at more than 15-pounds-per-square-inch gage.

   EXCEPTION: Aerosols.

6. Combustible dusts in suspension or capable of being put into suspension in the atmosphere of the room or area.

   EXCEPTIONS: 1. Rooms or areas used for woodworking where no more than three woodworking appliances having an aggregate exhaust requirement of less than 1,000 cubic feet per minute are utilized may be classified as Group B, Division 2 Occupancies, provided appliances are equipped with dust collectors sufficient to remove the dust generated by the appliances.

   2. Lumberyards and similar retail stores utilizing only power saws may be classified as Group B, Division 2 Occupancies.

The building official may revoke the use of these exceptions for due cause.

7. Class 3 oxidizers.

Division 3. Occupancies with a quantity of material in the building in excess of those listed in Table No. 9-A which present a high fire or physical hazard, including but not limited to:

1. Class II, III or IV organic peroxides.
2. Class 1 or 2 oxidizers.
3. Class I, II or III-A flammable liquids or combustible liquids which are utilized or stored in normally closed containers or systems and containers pressurized at 15-pounds-per-square-inch gage or less, and aerosols.
4. Class III-B combustible liquids.
5. Pyrophoric liquids or solids.
6. Water reactives.
7. Flammable solids, including combustible fibers or dusts, except for dusts included in Division 2.
8. Flammable or oxidizing cryogenic fluids (other than inert).
9. Class 1 or 2 unstable (reactive) materials.

Division 4. Repair garages not classified as Group B, Division 1.

Division 5. Aircraft repair hangars and heliports not classified as Group B, Division 3.

Division 6. Semiconductor fabrication facilities and comparable research and development areas when the facilities in which hazardous production materials (HPM) are used and aggregate quantity of materials are in excess of those listed in Table No. 9-A or 9-B.

Division 7. Occupancies having quantities of materials in excess of those listed in Table No. 9-B that are health hazards, including:

1. Corrosives.
2. Highly toxic materials.
3. Irritants.
4. Sensitizers.
5. Other health hazards.

Group I Occupancies:

Division 1. Nurseries for the full-time care of children under the age of six (each accommodating more than five persons).

Hospitals, sanitariums, nursing homes with nonambulatory patients and similar buildings (each accommodating more than five persons).

Division 2. Nursing homes for ambulatory patients, homes for children six years of age or over (each accommodating more than five persons).

Division 3. Mental hospitals, mental sanitariums, jails, prisons, reformatories, and buildings where personal liberties of inmates are similarly restrained.

> **EXCEPTION:** Group I Occupancies shall not include buildings used only for private residential purposes or for a family group.

Group M Occupancies:

Division 1. Private garages, sheds and agricultural buildings when not over 1000 square feet in area.

Division 2. Fences over 6 feet high, tanks and towers.

Group R Occupancies:

Division 1. Hotels and apartments. Congregate residences (each accommodating more than 10 persons).

Division 2. Not used.

Division 3. Dwellings and lodging houses.

Congregate residences (each accommodating 10 persons or less).

P

Sec. 418. PLENUM is an air compartment or chamber including unihabited crawl spaces, areas above a ceiling or below a floor, including air spaces below raised floors of computer/data processing centers, or attic spaces, to which one or more ducts are connected and which forms part of either the supply-air, return-air or exhaust-air system, other than the occupied space being conditioned.

PLUMBING CODE is the Uniform Plumbing Code promulgated by the International Association of Plumbing and Mechanical Officials as adopted by this jurisdiction.

PORTABLE COOLING UNIT is a self-contained refrigerating system, not over three horsepower rating, which has been factory assembled and tested, installed without supply-air ducts and without connecting any refrigerant-containing parts. This definition shall not include an absorption unit.

PORTABLE EVAPORATIVE COOLER is an evaporative cooler which discharges the conditioned air directly into the conditioned area without the use of ducts and can be readily transported from place to place without dismantling any portion thereof.

PORTABLE HEATING APPLIANCE is a heating appliance designed for environmental heating which may have a self-contained fuel supply and is not secured or attached to a building by any means other than by a factory-installed power-supply cord.

PORTABLE VENTILATING EQUIPMENT is ventilating equipment that can be readily transported from place to place without dismantling a portion thereof and which is not connected to a duct.

POSITIVE DISPLACEMENT COMPRESSOR is a compressor in which increase in pressure is attained by changing the internal volume of the compression chamber.

POWER BOILER PLANT. One or more power steam boilers or power hot-water boilers and connecting piping and vessels within the same premises.

PRESSURE-IMPOSING ELEMENT is a device or portion of the equipment used for the purpose of increasing the refrigerant vapor pressure.

PRESSURE-LIMITING DEVICE is a pressure-responsive mechanism designed to automatically stop the operation of the pressure-imposing element at a predetermined pressure.

PRESSURE-RELIEF DEVICE is a pressure-actuated valve or rupture member designed to automatically relieve excessive pressure.

PRESSURE VESSEL—REFRIGERANT is a refrigerant-containing receptacle which is a portion of a refrigeration system but shall not include evaporators, headers or piping.

Q

Sec. 419. No definitions.

R

Sec. 420. RADIANT HEATER is a heater designed to transfer heat primarily by direct radiation.

➡ **REFRIGERANT** is a substance used to produce refrigeration by its expansion or vaporization.

REFRIGERATING SYSTEM is a combination of parts in which a refrigerant is circulated for the purpose of extracting heat. For refrigerating system ratings one horsepower, one ton or 12,000 Btu/h shall mean the same quantity.

Absorption Refrigerating System, also an **Absorption System,** is a refrigerating system in which the gas evolved in the evaporator is taken up by an absorber or adsorber.

Mechanical Refrigerating System is one in which the gas evolved in the evaporator is compressed by mechanical means.

Absorption or **Mechanical Refrigerating Systems,** for the purpose of this code, are classified as follows:

Direct Refrigerating System is one in which the refrigerant evaporator is in direct contact with the material or space to be refrigerated or is located in air-circulating passages communicating with such spaces.

Indirect Refrigerating System is one in which a fluid cooled by a refrigerating system is circulated to the material or space to be refrigerated or is used to cool air so circulated.

REFRIGERATOR is a room or space in which an evaporator or brine coil is located for the purpose of reducing or controlling the temperature below 50°F.

RESIDENTIAL BUILDING is a building or portion thereof designed or used for human habitation.

RISER HEAT PIPE is a duct which extends at an angle of more than 45 degrees from the horizontal.

This definition shall not include any boot connection.

ROOM HEATER is a freestanding, nonrecessed, environmental heating appliance installed in the space being heated and not connected to ducts.

ROOM LARGE IN COMPARISON WITH SIZE OF EQUIPMENT is one having a volume of at least 12 times the total volume of a furnace or air-conditioning appliance and at least 16 times the total volume of a boiler. Total volume of the appliance is determined from exterior dimensions and includes fan compartments and burner vestibules when used. When the actual ceiling height of a room is greater than 8 feet, the volume of the room is figured on the basis of a ceiling height of 8 feet.

RUPTURE MEMBER is a pressure-relief device that operates by the rupture of a diaphragm within the device.

S

Sec. 421. SELF-CONTAINED means having all essential working parts except energy and control connections so contained in a case or framework that they do not depend on appliances or fastenings outside of the machine.

SHAFT is an interior space enclosed by walls or construction extending through one or more stories or basements which connects openings in successive floors or floors and roof, to accommodate elevators, dumbwaiters, mechanical equipment or similar devices to transmit light or ventilation air.

SHAFT ENCLOSURE is the walls or construction forming the boundaries of a shaft.

SMOKE DETECTOR is an approved device that senses visible or invisible particles of combustion.

SOLDERED JOINT is a joint obtained by the joining of metal parts with metallic mixtures or alloys which melt at a temperature below 800°F. and above 400°F.

STOP VALVE is a device to shut off the flow of refrigerant.

T

Sec. 422. No definitions.

U

Sec. 423. U.B.C. STANDARDS is the Uniform Building Code Standards promulgated by the International Conference of Building Officials, as adopted by this jurisdiction.

UNCONFINED SPACE is a room or space having a volume equal to at least 50 cubic feet per 1000 Btu/h of the aggregate input rating of all fuel-burning appliances installed in that space. Rooms communicating directly with the space in which the appliances are installed, through openings not furnished with doors, are considered a part of the unconfined space.

UNIT HEATER is a heating appliance designed for nonresidential space heating and equipped with an integral means for circulation of air.

UNIT REFRIGERATION SYSTEM is a refrigerating unit not to exceed three-horsepower rating and which has been factory assembled and tested prior to its installation. Such unit shall not be connected to any ductwork. The unit shall be a complete one-unit package without remote parts.

UNUSUALLY TIGHT CONSTRUCTION is construction where:

(a) Walls and ceilings exposed to the outside atmosphere have a continuous water vapor retarder with a rating of one perm or less with any openings gasketed or sealed, and

(b) Weatherstripping on openable windows and doors, and

(c) Caulking or sealants are applied to areas such as joints around window and door frames, between sole plates and floors, between wall-ceiling joints, between wall panels and at penetrations for plumbing, electrical and gas lines and at other openings.

V

Sec. 424. VENT is a listed factory-made vent pipe and vent fittings for conveying flue gases to the outside atmosphere.

Type B Gas Vent is a factory-made gas vent listed by a nationally recognized testing agency for venting listed or approved appliances equipped to burn only gas.

Type BW Gas Vent is a factory-made gas vent listed by a nationally recognized testing agency for venting listed or approved gas-fired vented wall furnaces.

Type L is a venting system consisting of listed vent piping and fittings for use with oil-burning appliances listed for use with Type L or with listed gas appliances.

VENT CONNECTOR, GAS, is that portion of a gas-venting system which connects a listed gas appliance to a gas vent.

VENTED DECORATIVE APPLIANCE is a vented appliance whose only function lies in the esthetic effect of the flames.

VENTED WALL FURNACE is a vented environmental heating appliance designed for incorporation in, or permanent attachment to, a wall, floor, ceiling or partition and arranged to furnish heated air by gravity or by a fan. This definition shall not include floor furnaces, unit heaters and room heaters.

VENTILATING CEILING is a suspended ceiling containing many small apertures through which air, at low pressure, is forced downward from an overhead plenum dimensioned by the concealed space between suspended ceiling and the floor or roof above.

VENTILATION SYSTEM is all of that equipment intended or installed for the purpose of supplying air to, or removing air from, any room or space by mechanical means, other than equipment which is a portion of an environmental heating, cooling, absorption or evaporative cooling system.

VENTING COLLAR is the outlet opening of an appliance provided for connection of the vent system.

VENTING SYSTEM is the vent or chimney and its connectors assembled to form a continuous open passageway from an appliance to the outside atmosphere for the purpose of removing products of combustion. This definition also shall include a venting assembly which is an integral part of an appliance.

VENTING SYSTEM—GRAVITY-TYPE is a system which depends entirely on the heat from the fuel being used to provide the energy required to vent an appliance.

VENTING SYSTEM—POWER-TYPE is a system which depends on a mechanical device to provide a positive draft within the venting system.

W

Sec. 425. WALL HEATER. See definition of Vented Wall Furnace.

WARM-AIR FURNACE is an environmental heating appliance designed or arranged to discharge heated air through any duct or ducts.

This definition shall not include a unit heater.

WATER HEATER or **HOT-WATER-HEATING BOILER** is an appliance designed primarily to supply hot water and is equipped with automatic controls limiting water temperature to a maximum of 210°F.

WELDED JOINT OR SEAM is any joint or seam obtained by the joining of metal parts in the plastic or molten state.

X, Y, Z—No definitions.

Part III

HEATING, VENTILATING AND COOLING

Chapter 5

EQUIPMENT—GENERAL

Scope

Sec. 501. Equipment shall conform to the requirements of this code.

Equipment shall not be installed or altered in violation of this code nor shall the fuel input rate to equipment be increased in excess of the approved Btu/h rating at the altitude where it is being used.

Defective material or parts shall be replaced in such a manner as not to invalidate any approval.

Approval

Sec. 502. (a) **How Obtained.** Each appliance shall be approved by the building official for safe use or comply with applicable nationally recognized standards as evidenced by the listing and label of an approved agency. Appendix C, Reference Standards, provides guidance as to available nationally recognized standards.

(b) **Complying Design of Equipment.** Installers shall furnish satisfactory evidence that the appliance is constructed in conformity with the requirements of this code. The permanently attached label of an approved agency may be accepted as such evidence.

Type of Fuel and Fuel Connections

Sec. 503. (a) **General.** Each appliance shall be designed for use with the type of fuel to which it will be connected. Appliances shall not be converted from the fuel specified on the rating plate for use with a different fuel without securing reapproval from the building official and as recommended by the manufacturer of either the original equipment or the conversion equipment. The serving gas supplier may convert appliances in accordance with procedures approved by the building official without securing reapproval of the appliance if properly relabeled.

An accessible approved shutoff valve shall be installed in the fuel-gas piping outside of each appliance and ahead of the union connection thereto in addition to any valve provided on the appliance. Such valve shall be within 3 feet of the appliance it serves, and in the same room or space where the applicance is located.

EXCEPTIONS: 1. Shutoff valves may be accessibly located inside or under an appliance when such appliance can be removed without removal of the shutoff valve.

2. Shutoff valves may be accessibly located inside wall heaters and wall furnaces listed for recessed installation where necessary maintenance can be performed without removal of the shutoff valve.

(b) **Oil-burning Appliances.** The tank, piping and valves for appliances burning oil shall be installed in accordance with the requirements of standards referenced in Appendix C.

(c) **Gas-burning Appliances.** Appliances designed to burn gas shall be rigidly connected to the gas-supply outlet in an approved manner and with approved materials.

> **EXCEPTION:** An approved listed semirigid or flexible metal tubing connector may be used to connect a gas appliance, provided:
>
> 1. The connector does not exceed 3 feet in length, except range and clothes dryer connectors, which may not exceed 6 feet.
> 2. An approved shutoff valve is used between the gas-supply outlet and such connector.
> 3. Connectors shall not be concealed within or run through any wall, floor or partition.
> 4. Connectors shall be of such size as to provide the total demand of the connected appliance load based on Table No. 5-D-1 or No. 5-D-2.

(d) **Pipe Size.** Additional fuel connections may be made to existing fuel-supply lines, provided pipe sizes are approved by the building official.

Installation

Sec. 504. (a) **Listed Appliances.** Except as otherwise provided in the code, the installation of appliances regulated by this code shall conform to the conditions of listing. The appliance installer shall leave the manufacturer's installation and operating instructions attached to the appliance. Clearances of listed appliances from combustible materials shall be as specified in the listing or on the rating plate.

(b) **Room Large in Comparison to Size of Equipment.** Central heating furnaces not listed for closet or alcove installation shall be installed in a room or space having a volume at least 12 times the total volume of the furnace; central heating boilers not listed for closet or alcove installation shall be installed in a room or space having a volume 16 times the volume of the boiler. If the ceiling height of the room or space is greater than 8 feet, the volume shall be calculated on the basis of 8-foot height.

(c) **Unlisted Appliance.** Unlisted appliances shall be installed with the standard clearances from combustible construction specified in Table No. 5-A. Unlisted appliances may have the standard clearances of Table No. 5-A reduced by employing the forms of protection specified in Table No. 5-B. Forms of protection specified in Table No. 5-B may be utilized to reduce clearances to combustible construction for all applicable appliances.

(d) **Anchorage of Appliances.** Appliances designed to be fixed in position shall be securely fastened in place. Supports for appliances shall be designed and constructed to sustain vertical and horizontal loads within the stress limitations specified in the Building Code.

(e) **Identification of Equipment.** When more than one heating, cooling, ventilating or refrigerating system is installed on the roof of a building or within the building, it shall be permanently identified as to the area or space served by the equipment.

(f) **LPG Appliances.** Liquefied petroleum gas-burning appliances shall not be installed in a pit, basement or similar location where heavier-than-air gas might collect. Appliances so fueled shall not be installed in an above-grade under-floor space or basement unless such location is provided with an approved means for removal of unburned gas.

Access

Sec. 505. Appliances shall be accessible for inspection, service, repair and replacement without removing permanent construction.

Unless otherwise specified, not less than 30 inches of working space and platform shall be provided to service the appliance.

> **EXCEPTION:** Unit heaters and room heaters may be installed with an 18-inch minimum working space. A platform shall not be required for unit heaters or room heaters.

The operating instructions shall be attached to the appliance where they can be read easily.

Automatic Control Devices

Sec. 506. Heating appliances shall be equipped with a listed device or devices which will shut off the fuel supply to the main burner or burners in the event of pilot or ignition failure. In addition, liquefied petroleum gas-air-burning heating appliances shall be equipped with a listed automatic device or devices which will shut off the flow of gas to the pilot in the event of ignition failure.

> **EXCEPTION:** The listed shutoff devices shall not be required on range or cooking tops, log lighters, lights or other open-burner manually operated appliances, or listed appliances not requiring such devices and specific industrial appliances as approved by the building official.

Heating appliances whose manual fuel controls are not readily accessible from the main portion of the building being heated shall be equipped with remote controls.

Forced-air and gravity-type warm-air furnaces shall be equipped with a listed air-outlet temperature limit control which cannot be set for temperatures higher than 250°F. Such controls shall be located in the bonnet or plenum, within 2 feet of the discharge side of the heating element of gravity furnaces or in accordance with the conditions of listing.

Electric duct heaters shall be equipped with an approved automatic reset air outlet temperature limit control that will limit the outlet air temperature to not more than 200°F. The electric elements of the heater shall be equipped with fusible links or a manual reset temperature limit control that will prevent outlet air temperature in excess of 250°F.

Labeling

Sec. 507. (a) **Fuel-burning Appliances.** Fuel-burning heating appliances shall bear a permanent and legible factory-applied nameplate on which shall appear:

1. The manufacturer's name.
2. The approved fuel input rating of the appliance, expressed in Btu/h.
3. The model and serial number.
4. Instructions for the lighting, operation and shutdown of the appliance.
5. The type of fuel approved for use with the appliance.
6. The symbol of an approved agency certifying compliance of equipment with recognized standards.
7. Required clearances from combustible surfaces on which or adjacent to which it may be mounted.

(b) **Electric Heating Appliances.** Electric heating appliances shall bear a permanent and legible factory-applied nameplate on which shall appear:

1. Name or trademark of the manufacturer.
2. The catalog (model) number or equivalent.
3. The electrical rating in volts, amperes (or watts) and, for other than single phase, the number of phases.

In addition, the appliance shall be permanently and legibly marked at the factory with:

A. The output rating in Btu/h or kW.

B. The electrical rating in volts, amperes or watts of each field-replaceable electrical component.

C. The symbol of an approved agency certifying compliance of equipment with recognized standards.

D. Required clearances from combustible surfaces on which or adjacent to which it may be mounted.

Also, it shall be accompanied by clear and complete installation instructions, including required clearances from combustibles other than mounting or adjacent surfaces, and temperature rating of field-installed wiring connections if over 60°C.

(c) **Heat Pump Appliances.** Heat pumps shall bear a permanent and legible factory-applied nameplate on which shall appear:

1. Name or trademark of the manufacturer.
2. Catalog model nomenclature.
3. Amount and type of refrigerant.
4. Factory test pressures or pressures applied.
5. The symbol of an approved agency certifying compliance of the equipment with recognized standards.

Location

Sec. 508. Appliances installed in garages, warehouses or other areas where they may be subjected to mechanical damage shall be suitably guarded against such damage by being installed behind protective barriers or by being elevated or located out of the normal path of vehicles.

Heating and cooling equipment located in a garage and which generates a glow, spark or flame capable of igniting flammable vapors shall be installed with the pilots and burners or heating elements and switches at least 18 inches above the floor level.

Where such appliances installed within a garage are enclosed in a separate, approved compartment having access only from outside of the garage such appliances may be installed at floor level, provided the required combustion air is taken from and discharged to the exterior of the garage.

Heating equipment located in rooms where cellulose nitrate plastic is stored or processed shall comply with the Fire Code.

Electrical Connections

Sec. 509. Equipment regulated by this code requiring electrical connections of more than 50 volts shall have a positive means of disconnect adjacent to and in sight from the equipment served. A 120-volt receptacle shall be located within 25 feet of the equipment for service and maintenance purposes. The receptacle need not be located on the same level as the equipment. Low-voltage wiring of 50 volts or less within a structure shall be installed in a manner to prevent physical damage.

Condensate Wastes

Sec. 510. (a) **Condensate Disposal.** Condensate from air-cooling coils, fuel-burning condensing appliances and the overflow from evaporative coolers and similar water-supplied equipment shall be collected and discharged to an approved plumbing fixture or disposal area. The waste pipe shall have a slope of not less than 1/8 inch per foot and shall be of approved corrosion-resistant material not smaller than the outlet size as required in either Subsection (b) or (c) below for air-cooling coils or condensing fuel-burning appliances, respectively. Condensate or waste water shall not drain over a public way.

(b) **Condensate Waste Sizing.** Condensate wastes pipes from air-cooling coils shall be sized in accordance with equipment capacity as follows:

Equipment Capacity	Minimum Condensate Pipe Diameter
Up to 20 tons of refrigeration	3/4 inch
21 to 40 tons of refrigeration	1 inch
41 to 90 tons of refrigeration	1 1/4 inch
91 to 125 tons of refrigeration	1 1/2 inch
126 to 250 tons of refrigeration	2 inch

The size of condensate waste pipes may be for one unit or a combination of units, or as recommended by the manufacturer. The capacity of waste pipes assumes a 1/8-inch-per-foot slope, with the pipe running three-quarters full:

Outside Air—20%		**Room Air—80%**	
DB	WB	DB	WB
90°F.	73°F.	75°F.	62.5°F.

Condensate drain sizing for other slopes or other conditions shall be approved by the building official.

(c) **Fuel-burning Appliance Condensate Drains.** Condensate drain lines from individual fuel-burning condensing appliances shall be sized according to the manufacturers' recommendations. Condensate drain lines serving more than one appliance shall be approved by the building official prior to installation.

Personnel Protection

Sec. 511. A suitable and substantial metal guard shall be provided around exposed flywheels, fans, pulleys, belts and moving machinery which are portions of a heating, ventilating or refrigerating system.

TABLE NO. 5-A—STANDARD INSTALLATION CLEARANCES IN INCHES FOR UNLISTED HEAT-PRODUCING APPLIANCES SEE SECTION 504

RESIDENTIAL-TYPE APPLIANCES	FUEL	APPLIANCE				
		ABOVE TOP OF CASING OR APPLIANCE	FROM TOP AND SIDES OF WARM-AIR BONNET OR PLENUM	FROM FRONT[1]	FROM BACK	FROM SIDES
BOILERS AND WATER HEATERS Steam Boilers—15 psi Water Boilers—250°F. Water Heaters—200°F. All Water Walled or Jacketed	Automatic Oil or Comb. Gas-Oil	6		24	6	6
	Automatic Gas	6		18	6	6
	Solid	6		48	6	6
FURNACES—CENTRAL; OR HEATERS—ELECTRIC CENTRAL WARM-AIR FURNACES Gravity, Upflow, Downflow, Horizontal and Duct Warm-air—250°F. Max.	Automatic Oil or Comb. Gas-Oil	6[2]	6[2]	24	6	6
	Automatic Gas	6[2]	6[2]	18	6	6
	Solid	18[3]	18[3]	48	18	18
	Electric	6[2]	6[2]	18	6	6
FURNACES—FLOOR For Mounting in Combustible Floors	Automatic Oil or Comb. Gas-Oil	36		12	12	12
	Automatic Gas	36		12	12	12
HEAT EXCHANGER Steam—15 psi Max. Hot Water—250°F. Max.		1	1	1	1	1
ROOM HEATERS[4] Circulating Type	Oil or Solid	36		24	12	12
	Gas	36		24	12	12
ROOM HEATERS[4] (cont.) Radiant or Other Type	Oil or Solid	36		36	36	36
	Gas	36		36	18	18
	Gas with double metal or ceramic back	36		36	12	18
Fireplace Stove	Solid	48[5]		54	48[5]	48[5]

(Continued)

TABLE NO. 5-A—STANDARD INSTALLATION CLEARANCES IN INCHES FOR UNLISTED HEAT-PRODUCING APPLIANCES SEE SECTION 504—(Continued)

RESIDENTIAL-TYPE APPLIANCES	FUEL	APPLIANCE FROM TOP AND SIDES ABOVE TOP OF CASING OR APPLIANCE	FROM TOP AND SIDES OF WARM-AIR BONNET OR PLENUM	FROM FRONT[1]	FROM BACK	FROM SIDES	
RADIATORS Steam or Hot Water[6]		36		6	6	6	
RANGES—COOKING STOVES						Firing Side	Opp. Side
	Oil	30[7]			9	24	18
	Gas	30[7]			6	6	6
	Solid Clay-lined Firepot	30[7]			24	24	18
	Solid Unlined Firepot	30[7]			36	36	18
	Electric	30[7]			6	6	
INCINERATORS Domestic Types		36[8]		48	36	36	

COMMERCIAL INDUSTRIAL-TYPE LOW-HEAT APPLIANCES ANY AND ALL PHYSICAL SIZES EXCEPT AS NOTED	FUEL	APPLIANCE ABOVE TOP OF CASING OR APPLIANCE[9]	FROM TOP AND SIDES OF WARM-AIR BONNET OR PLENUM	FROM FRONT[1]	FROM BACK[9]	FROM SIDES[9]
BOILERS AND WATER HEATERS 100 cu. ft. or less Any psi Steam	All Fuels	18		48	18	18
50 psi or less Any Size	All Fuels	18		48	18	18

COMMERCIAL INDUSTRIAL-TYPE LOW-HEAT APPLIANCES ANY AND ALL PHYSICAL SIZES EXCEPT AS NOTED		APPLIANCE				
	FUEL	ABOVE TOP OF CASING OR APPLIANCE	FROM TOP AND SIDES OF WARM-AIR BONNET OR PLENUM	FROM FRONT[1]	FROM BACK	FROM SIDES
UNIT HEATERS Floor Mounted or Suspended—Any Size	Steam or Hot Water	1			1	1
Suspended—100 cu. ft. or less	Oil or Comb. Gas-Oil	6		24	18	18
Suspended—100 cu. ft. or less	Gas	6		18	18	18
Suspended—Over 100 cu. ft.	All Fuels	18		48	18	18
Floor Mounted—Any Size	All Fuels	18		48	18	18
RANGES—RESTAURANT-TYPE Floor Mounted	All Fuels	48		48	18	18
OTHER LOW-HEAT INDUSTRIAL APPLIANCES Floor Mounted or Suspended	All Fuels	18	18	48	18	18

(Continued)

TABLE NO. 5-A—STANDARD INSTALLATION CLEARANCES IN INCHES FOR UNLISTED HEAT-PRODUCING APPLIANCES SEE SECTION 504—(Continued)

COMMERCIAL INDUSTRIAL-TYPE MEDIUM-HEAT APPLIANCES		APPLIANCE				
	FUEL	ABOVE TOP OF CASING OR APPLIANCE[10]	FROM TOP AND SIDES OF WARM-AIR BONNET OR PLENUM	FROM FRONT[1]	FROM BACK[10]	FROM SIDES[10]
BOILERS AND WATER HEATERS Over 50 psi Over 100 cu. ft.	All Fuels	48		96	36	36
OTHER MEDIUM-HEAT INDUSTRIAL APPLIANCES All Sizes	All Fuels	48	36	96	36	36
INCINERATORS All Sizes		48		96	36	36
INDUSTRIAL-TYPE HIGH-HEAT APPLIANCES						
HIGH-HEAT INDUSTRIAL APPLIANCES All Sizes	All Fuels	180		360	120	120

FOOTNOTES FOR TABLE NO. 5-A

[1] The minimum dimension shall be that necessary for servicing the appliance, including access for cleaning and normal care, tube removal, etc.

[2] For a listed oil, combination gas-oil, gas or electric furnace this dimension may be 2 inches if the furnace limit control cannot be set higher than 250°F., or this dimension may be 1 inch if the limit control cannot be set higher than 200°F., or the appliance shall be marked to indicate that the outlet air temperature cannot exceed 200°F.

[3] The dimension may be 6 inches for an automatically stoker-fired forced-warm-air furnace equipped with 250°F. limit control and with barometric draft control operated by draft intensity and permanently set to limit draft to a maximum intensity of 0.13-inch water gage.

[4] Approved appliances shall be installed on noncombustible floors and may be installed on protected combustible floors. Heating appliances approved for installation on protected combustible flooring shall be so constructed that flame and hot gases do not come in contact with the appliance base. Protection for combustible floors shall consist of 4-inch hollow masonry covered with sheet metal at least 0.021 inch thick (No. 24 manufacturer's standard gage). Masonry shall be permanently fastened in place in an approved manner with the ends unsealed and joints matched so as to provide free circulation of air through the masonry. Floor protection shall extend 12 inches at the sides and rear of the appliance, except that at least 18 inches shall be required on the appliance-opening side or sides measured horizontally from the edges of the opening.

[5] The 48-inch clearance may be reduced to 36 inches when protection equivalent to that provided by Items (a) through (g) of Table No. 5-B is applied to the combustible construction.

[6] Steampipes and hot-water heating pipes shall be installed with a clearance of at least 1 inch to all combustible construction or material, except that at the points where pipes carrying steam at not over 15 pounds gage pressure or hot water emerge from a floor, wall or ceiling, the clearance at the opening through the finish floorboards or wall-ceiling boards may be reduced to not less than 1/2 inch. Each such opening shall be covered with a plate of noncombustible material.

Such pipes passing through stock shelving shall be covered with not less than 1 inch of approved insulation.

Wood boxes or casings enclosing uninsulated steam or hot-water heating pipes or wooden covers to recesses in walls in which such uninsulated pipes are placed shall be lined with metal or insulating millboard.

Where the temperature of the boiler piping does not exceed 160°F., the provisions of this table shall not apply.

Coverings or insulation used on steam or hot-water pipes shall be of material suitable for the operating temperature of the system. The insulation or jackets shall be of noncombustible materials, or the insulation or jackets and lap-seal adhesives shall be tested as a composite product. Such composite product shall have a flame-spread rating of not more than 25 and a smoke-developed rating not to exceed 50 when tested in accordance with U.B.C. Standard No. 42-1.

[7] To combustible material or metal cabinets. If the underside of such combustible material or metal cabinet is protected with insulating millboard at least 1/4 inch thick covered with sheet metal of not less than 0.013 inch (No. 28 gage), the distance may be reduced to 24 inches.

[8] Clearance above charging door shall be at least 48 inches.

[9] If the appliance is encased in brick, the 18-inch clearance above and at sides and rear may be reduced to 12 inches.

[10] If the appliance is encased in brick, the clearance above may be reduced to 36 inches and at sides and rear may be reduced to 18 inches.

TABLE NO. 5-B—CLEARANCES, INCHES, WITH SPECIFIED FORMS OF PROTECTION[1,2]

TYPE OF PROTECTION Applied to the Combustible Material Unless Otherwise Specified and Covering All Surfaces Within the Distance Specified as the Required Clearance With No Protection (Thicknesses are Minimum)	WHERE THE STANDARD CLEARANCE IN TABLE NO. 5-A WITH NO PROTECTION IS:											
	36 Inches			18 Inches			12 Inches		9 Inches	6 Inches		
	Above	Sides and Rear	Chimney or Vent Connector	Above	Sides and Rear	Chimney or Vent Connector	Above	Sides and Rear	Chimney or Vent Connector	Above	Sides and Rear	Chimney or Vent Connector
(a) 1/4″ in insulating millboard spaced out 1″[3]	30	18	30	15	9	12	9	6	6	3	2	3
(b) 0.013″ (No. 28 manufacturer's standard gage) steel sheet on 1/4″ insulating millboard	24	18	24	12	9	12	9	6	4	3	2	2
(c) 0.013″ (No. 28 manufacturer's standard gage) steel sheet spaced out 1″[3]	18	12	18	9	6	9	6	4	4	2	2	2
(d) 0.013″ (No. 28 manufacturer's standard gage) steel sheet on 1/8″ insulating millboard spaced out 1″[3]	18	12	18	9	6	9	6	4	4	2	2	2
(e) 1 1/2″ insulating cement covering on heating appliance	18	12	36	9	6	18	6	4	9	2	1	6
(f) 1/4″ insulating millboard on 1″ mineral fiber batts reinforced with wire mesh or equivalent	18	12	18	6	6	6	4	4	4	2	2	2
(g) 0.027″ (No. 22 manufacturer's standard gage) steel sheet on 1″ mineral fiber batts reinforced with wire or equivalent	18	12	12	4	3	3	2	2	2	2	2	2
(h) 1/4″ insulating millboard	36	36	36	18	18	18	12	12	9	4	4	4

[1] For appliances complying with Sections 504 (b) and (c)

[2] Except for the protection described in (e), all clearances shall be measured from the outer surface of the appliance to the combustible material, disregarding any intervening protection applied to the combustible material.

[3] Spacers shall be of noncombustible material.

Note: Insulating millboard is a factory made product formed of noncombustible materials, normally fibers, and having a thermal conductivity of 1 Btu-inch per square foot per degree F. or less.

TABLE NO. 5-C—CHIMNEY CONNECTOR AND VENT CONNECTOR CLEARANCES FROM COMBUSTIBLE MATERIALS

DESCRIPTION OF APPLIANCE	MINIMUM CLEARANCE INCHES[1]
RESIDENTIAL-TYPE APPLIANCES	
Single-wall Metal Pipe Connectors[2]	
Gas appliances without draft hoods	18
Electric, gas and oil incinerators	18
Oil and solid-fuel appliances	18
Unlisted gas appliances with draft hoods	9
Boilers and furnaces equipped with listed gas burners and with draft hoods	9[3]
Oil appliances listed as suitable for use with Type L venting systems (but only when connected to chimneys)	9
Listed gas appliances with draft hood.	6
Type L Venting System Piping Connectors	
Gas appliances without draft hoods	9
Electric, gas and oil incinerators	9
Oil and solid-fuel appliances	9
Unlisted gas appliances with draft hoods	6
Boilers and furnaces equipped with listed gas burners and with draft hoods	6
Oil appliances listed as suitable for use with Type L venting systems	—[4]
Listed gas appliances with draft hoods	—[5]
Type B Gas Vent Piping Connectors	
Listed gas appliances with draft hoods	—[5]
COMMERCIAL-INDUSTRIAL TYPE APPLIANCES	
Low-heat Appliances	
Single-wall Metal Pipe Connectors[2]	
Gas, oil and solid-fuel boilers, furnaces and water heaters	18
Ranges, restaurant-type	18
Oil unit heaters	18
Unlisted gas unit heaters	18
Listed gas unit heaters with draft hoods	6
Other low-heat industrial appliances	18
Medium-heat Appliances	
Single-wall Metal Pipe Connectors[2]	
All gas, oil and solid-fuel appliances	36

[1] These clearances apply except if the listing of an appliance specifies different clearance, in which case the listed clearance takes precedence.

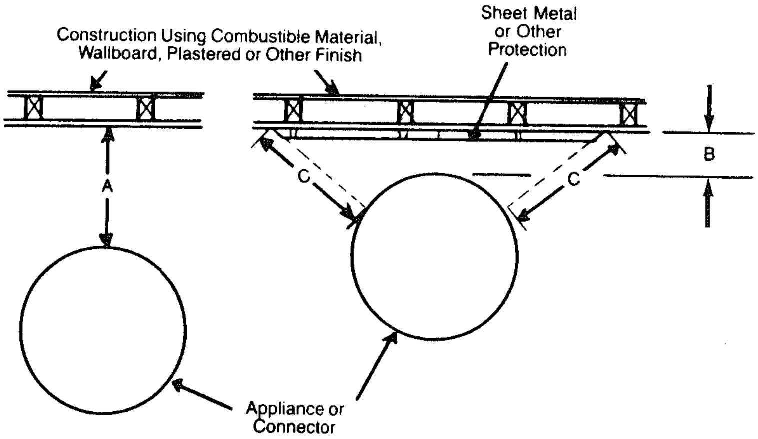
[2] The clearances from connectors to combustible materials may be reduced if the combustible material is protected in accordance with Table No. 5-B.

[3] The dimension may be 6 inches, provided the maximum flue temperatures entering the draft hood do not exceed 550°F.

[4] If listed Type L venting system piping is used, the clearance may be in accordance with the venting system listing.

[5] If listed Type B or Type L venting system piping is used, the clearance may be in accordance with the venting system listing.

FIGURE NO. 1—EXTENT OF PROTECTION REQUIRED TO REDUCE CLEARANCES FROM APPLIANCE, CHIMNEY OR VENT CONNECTORS


Construction Using Combustible Material, Wallboard, Plastered or Other Finish
Sheet Metal or Other Protection
A
B
C
C
Appliance or Connector

A—Dimension shall be not less than the required clearance with no protection set forth in Tables No. 5-A and No. 5-C and in the sections applying to various types of appliances.

B—Dimension shall be not less than the reduced clearance set forth in Table No. 5-B.

C—Dimension shall be not less than the clearance required for dimension A.

TABLE NO. 5-D-1—CAPACITIES OF LISTED METAL APPLIANCE CONNECTORS[1]

For use with gas pressures 8-inch or more water column

Semirigid Connector O.D.[2] (Inch)	Flexible Connector Nominal I.D.[3] (Inch)	Maximum Capacities in Thousands Btu/h (Based on pressure drop of 0.4-inch water column) Nat. Gas[4] of 1100 Btu/cu. ft.							
		1′	1 1/2′	2′	2 1/2′	3′	4′	5′	6′
		All Gas Appliances					Ranges and Clothes Dryers		
3/8	1/4	40	33	29	27	25	101	90	80
1/2	3/8	93	76	66	62	58			
5/8	1/2	189	155	134	125	116			
—	3/4	404	330	287	226	244			
—	1	803	661	573	534	500			

[1] Gas connectors are certified by the testing agency as complete assemblies including the fittings and valves. Capacities shown are based on the use of fittings and valves supplied with the connector.

[2] Outside diameter.

[3] Internal diameter.

[4] For liquefied petroleum gas use 1.6 times the natural gas capacities shown.

TABLE NO. 5-D-2—CAPACITIES OF LISTED METAL APPLIANCE CONNECTORS[1]

For use with gas pressures less than 8-inch water column

Semirigid Connector O.D.[2] (Inch)	Flexible Connector Nominal I.D.[3] (Inch)	Capacities for Various Lengths in Thousands Btu/h (Based on pressure drop of 0.4-inch water column Nat. Gas[4] of 1100 Btu/cu. ft.							
		1′	1 1/2′	2′	2 1/2′	3′	4′	5′	6′
		All Gas Appliances					Ranges and Clothes Dryers		
3/8	1/4	28	23	20	19	17	72	63	57
1/2	3/8	66	54	47	44	41			
5/8	1/2	134	110	95	88	82			
—	3/4	285	233	202	188	174			
—	1	567	467	405	378	353			

[1] Gas connectors are certified by the testing agency as complete assemblies including the fittings and valves. Capacities shown are based on the use of fittings and valves supplied with the connector.

[2] Semirigid connector listings are based on outside diameter.

[3] Flexible connector listings are based on nominal diameter.

[4] For liquefied petroleum gas use 1.6 times the natural gas capacities shown.

Chapter 6
COMBUSTION AIR

General

Sec. 601. (a) **Air Supply.** Fuel-burning equipment shall be assured a sufficient supply of combustion air. The methods of providing combustion air in this chapter do not apply to direct vent appliances, appliances listed as having separated combustion systems, enclosed furnaces, listed cooking appliances, refrigerators and domestic clothes dryers.

In buildings of unusually tight construction, combustion air shall be obtained from outside. In buildings of ordinary tightness insofar as infiltration is concerned, all or a portion of the combustion air for fuel-burning appliances may be obtained from infiltration when the requirement for 50 cubic feet per 1,000 Btu/h input is met.

(b) **Existing Buildings.** When fuel-burning appliances are installed in an existing building containing other fuel-burning appliances, the room or space shall be provided with combustion air as required by this chapter for all fuel-burning appliances contained therein.

Combustion Air Openings

Sec. 602. (a) **Location.** One opening shall be located within the upper 12 inches of the enclosure and one opening shall be located within the lower 12 inches of the enclosure.

(b) **Dampers Prohibited.** Combustion air ducts or plenums shall not be installed so as to require openings in or penetrations through construction where fire dampers are required. Manually-operated dampers shall not be installed in combustion air openings. With prior approval, power-actuated movable louvers admitting combustion air may be used and, if installed, shall be electrically interlocked with the main burner fuel-supply valve so as to prevent fuel delivery unless the louvers are in the fully open position.

(c) **Louvers, Grilles and Screens.** Combustion air openings shall be covered with corrosion-resistant screen of 1/4-inch mesh, except as provided in Section 604 (c). In calculating the free area, consideration shall be given to the blocking effect of louvers, grilles and screens protecting openings. The free area through louvers, grilles and screens shall be used in calculating the size of opening required to provide the free area specified.

Sources of Combustion Air

Sec. 603. (a) **Air from Outside.** Combustion air obtained from outside the building shall be supplied as follows:

1. Through permanent openings of the required area directly to the outside of the building through the floor, roof or walls of the appliance enclosure; or,

2. Through continuous ducts of the required cross-sectional area extending from the appliance enclosure to the outside of the building. The required upper combustion air duct shall extend horizontally or upwards to the outside of the

building. Where not otherwise prohibited, combustion air may be obtained from an attic area, provided the attic ventilating openings are not subject to ice or, snow blockage, and further provided:

A. The attic has not less than 30 inches vertical clear height at its maximum point.

B. Attic ventilation is sufficient to provide the required volume of combustion air and complies with the requirements of Section 606.

C. The combustion-air opening is provided with a galvanized sleeve of not less than 0.019-inch (No. 26 gage) steel or other approved material extending from the appliance enclosure to at least 6 inches above the top of the ceiling joists and insulation.

(b) **Under-floor Supply.** Lower combustion air openings may connect with under-floor areas conforming to the following requirements:

1. Under-floor spaces having unobstructed openings to the exterior at least twice the area of the required air openings.

2. The height of the under-floor space shall comply with the requirements of the Building Code and be without obstruction to the free flow of air.

(c) **Prohibited Sources.** Openings and ducts shall not connect appliance enclosures with space in which the operation of a fan may adversely affect the flow of combustion air. Combustion air shall not be obtained from a hazardous location or from any area in which objectionable quantities of flammable vapor, lint or dust are released. Combustion air shall not be taken from a refrigeration machinery room.

(d) **Interior Spaces.** In buildings of ordinary tightness, combustion air provided by infiltration may be obtained from freely communicating interior spaces, provided the combined volume in cubic feet complies with the following conditions:

1. **Adequate volume—gas and liquid.** If the volume of the room or space in which fuel-burning appliances are installed is equal to or greater than 50 cubic feet per 1000 Btu/h of aggregate input rating of appliances, infiltration may be regarded as adequate to provide combustion air. Exclude from the calculation the input ratings of listed direct vent appliances, enclosed furnaces, cooking appliances, refrigerators and domestic clothes dryers.

2. **Insufficient volume—gas and liquid.** Rooms or spaces containing gas- or liquid-fuel-burning appliances which do not have the volume as specified above shall be provided with minimum unobstructed combustion air openings as specified in Section 607 and arranged as specified in Sections 602.

Combustion Air Ducts

Sec. 604. (a) **General.** Combustion air ducts shall:

1. Be of galvanized steel complying with Chapter 10 or equivalent corrosion-resistant material approved for this use.

> **EXCEPTION:** In Group R, Division 3 Occupancies, unobstructed stud and joist spaces may be used, provided not more than one required fire stop is removed.

2. Have a minimum cross-sectional dimension of 3 inches.

3. Terminate in a space at least 3 inches in depth open to the front or firebox side of the appliance. Such space shall extend from the floor to the ceiling of the appliance enclosure.

4. Have the same cross-sectional areas as the free area of the openings to which they connect.

5. Serve a single appliance enclosure.

6. Serve only upper or lower combustion air openings; the separation between ducts serving upper and lower combustion air openings shall be maintained to the source of combustion air.

(b) **Dampers.** Combustion air ducts shall not be installed so as to pass through construction where fire dampers are required. Volume dampers shall not be installed in combustion air ducts.

(c) **Screen.** Neither end of ducts which terminate in an attic shall be screened.

Gravity-type Warm-air Furnaces

Sec. 605. Gravity-type warm-air furnaces shall be provided with combustion air as specified in Section 601, 602, 603 or 607 of this code. Combustion and cold-air return for gravity-type warm-air furnaces may be obtained from the same area.

Special Conditions Created by Mechanical Exhausting or Fireplaces

Sec. 606. Operation of exhaust fans, kitchen ventilation systems, clothes dryers or fireplaces shall be considered in determining combustion air requirements to avoid unsatisfactory operation of installed gas appliances.

Area of Combustion Air Openings

Sec. 607. (a) **General.** The net free area of openings, ducts or plenums supplying combustion air to an area containing fuel-burning appliances shall be as specified in Table No. 6-A. When grilles, screens or louvers are inserted in combustion-air openings, the provisions of Section 602 (c) apply. Permanent mechanically pressurized combustion-air facilities in central heating plants, fossil-fueled steam electric generating plants, district heating plants, industrial facilities and power boiler plants are exempt from the requirements of Table No. 6-A.

(b) **Designed Installations.** Compliance with Table No. 6-A is not required for an installation which has been professionally designed to ensure an adequate supply of combustion air.

TABLE NO. 6-A
SIZE OF COMBUSTION-AIR OPENINGS OR DUCTS[1]

COLUMN I		COLUMN II	
Buildings of Ordinary Tightness		Buildings of Unusually Tight Construction[2]	
Condition	Size of Openings or Ducts	Condition	Size of Openings or Ducts
Appliance in unconfined[2] space:	May rely on infiltration alone.	**Appliance in unconfined[2] space:** Obtain combustion air from outdoors or from space freely communicating with outdoors.	Provide two openings, each having 1 sq. in. per 5,000 Btu/h input. Ducts admitting outdoor air may be connected to the cold-air return.
Appliance in confined[4] space: 1. All air from inside building.	Provide two openings into enclosure each having one square inch per 1000 Btu/h input freely communicating with other unconfined interior spaces. Minimum 100 sq. in. each opening.[3]	**Appliance in confined[4] space:** Obtain combustion air from outdoors or from space freely communicating with outdoors.	1. Provide two **vertical ducts** or plenums; 1 sq. in. per 4,000 Btu/h input each duct or plenum. 2. Provide two **horizontal ducts** or plenums; 1 sq. in. per 2,000 Btu/h input each duct or plenum.

COLUMN I		COLUMN II	
Buildings of Ordinary Tightness		Buildings of Unusually Tight Construction[2]	
Condition	Size of Openings or Ducts	Condition	Size of Openings or Ducts
2. Part of air from inside building.	Provide two openings into enclosure[3] from other freely communicating unconfined[2] interior spaces each having an area of 100 sq. in. plus one duct or plenum opening to outdoors having an area of 1 sq. in. per 5,000 Btu/h input rating. The outdoor duct or plenum opening may be connected to the cold-air return.		3. Provide two **openings in** an **exterior wall** of the enclosure; each opening 1 sq. in. per 4,000 Btu/h input. 4. Provide one **ceiling opening** to ventilated attic **and** one **vertical duct** to attic; each opening 1 sq. in. per 4,000 Btu/h input.
3. All air from outdoors. Obtain from outdoors or from space freely communicating with outdoors.	Use any of the methods listed for confined space in unusually tight construction as indicated in Column II.		5. Provide one **opening in** enclosure **ceiling** to ventilated attic and one **opening in** enclosure **floor** to ventilated crawl space; each opening 1 sq. in. per 4,000 Btu/h input.

[1] For location of openings see Section 602.

[2] As defined in Section 423.

[3] When the total input rating of appliances in enclosure exceeds 100,000 Btu/h, the area of each opening into the enclosure shall be increased 1 square inch for each 1,000 Btu/h over 100,000.

[4] As defined in Section 405.

Chapter 7

WARM-AIR HEATING SYSTEMS

Scope

Sec. 701. Provisions of this chapter apply to warm-air furnaces and heating systems. In addition to the general requirements of Chapter 5, warm-air furnaces and heating systems shall be installed to conform to the requirements of this chapter.

General

Sec. 702. A room or space containing a fuel-burning warm-air furnace shall be provided with combustion air as specified in Chapter 6.

Fuel-burning warm-air furnaces shall be vented as specified in Chapter 9.

Air ducts and plenums which are a portion of a heating system shall comply with Chapter 10.

Heating systems shall be installed so as to minimize the probability of damage from an external source.

Access

Sec. 703. A furnace room shall have an opening or door and passageway thereto not less than 2 feet in width and large enough to permit removal of the largest furnace in such room. The furnace shall be installed so as to permit removal without disturbing piping, conduits, appurtenant valves and junction boxes.

> **EXCEPTIONS:** 1. When the furnace room is large enough to permit dismantling the furnace within the room, the access opening and passageway need be large enough only to permit removal of the largest piece of furnace. This exception shall not be construed to waive the requirements of a minimum door and passageway of 2 feet.
>
> 2. Access to warm-air furnaces installed in under-floor spaces shall comply with Section 709.
>
> 3. Access to warm-air furnaces installed in an attic or furred space shall comply with Section 708.
>
> 4. Access to warm-air furnaces installed on a roof or on an outside wall structure shall comply with Section 710.

An unobstructed working space not less than 30 inches in depth and the height of the furnace, but not less than 30 inches, shall be provided along the entire front or firebox side of every warm-air furnace when the door of the furnace enclosure is open.

Heating system air filters, fuel-control valves, vent collars, air-handling units and externally mounted controls shall be accessible for maintenance, repair and replacement. Access space shall be as specified for cooling equipment in Section 1202.

Prohibited Installations

Sec. 704. Warm-air furnaces shall not be installed:

1. In a closet or alcove less than 12 inches wider than the furnace or furnaces

installed therein with a minimum clear working space less than 3 inches along the sides, back and top of the furnace.

> **EXCEPTION:** Replacement forced-air furnaces or air-conditioning cooling coils may be installed in an existing closet or alcove with lesser width and depth when approved by the building official and provided that such width and depth is in compliance with conditions of listing. Combustion air openings at the rear or side of the closet shall meet the requirements of Chapter 6.

2. In a hazardous location.

3. In a surgical operating room or medical treatment room.

4. In an occupancy, unless separated by fire-resistive construction from the rest of the building as required by the special hazards sections of Part III of the Building Code.

5. In a room used or designed to be used as a bedroom, bathroom, closet or in any enclosed space with access only through such room or space.

> **EXCEPTION:** Direct vent furnaces, enclosed furnaces and electric heating furnaces. Access to furnaces located in an attic or under-floor crawl space may be through a closet.

6. Outside of a building unless listed for exterior installation or enclosed in a weatherproof housing complying with Section 710.

7. With clearance along the combustion chamber opening side of less than 6 inches or working space along the entire front or firebox side less than specified in Section 703.

Installation

Sec. 705. A furnace shall not be installed on the discharge side of a refrigerant evaporator or other air-cooling coil unless the furnace is specifically listed for such use. A furnace shall not be installed on the discharge side of an evaporative cooler unless the heat exchanger is of approved corrosion-resistant material.

A refrigerant evaporator or other air-cooling coil may be installed in the air-discharge duct of a heating furnace if the furnace is listed for use with an air-cooling coil or is listed for operation at at least 0.5 water column static pressure and conforms with Part IV of this code. Conversion of existing furnaces for use with cooling coils is permissible if authorized by the manufacturer and approved by the building official.

A furnace supported from the ground shall rest on a concrete slab extending not less than 3 inches above the adjoining ground level.

Return and Outside Air

Sec. 706. (a) **Source.** A warm-air furnace shall be provided with return air, outside air, or both. Heating systems regulated by this code and designed to replace required ventilation shall be arranged to discharge into the conditioned space not less than the amount of outside air specified in the Building Code.

(b) **Separation.** Except as permitted by the exceptions to Subsection (f) of this section, there shall be a positive separation between combustion air and outside or return air for blower-type heating systems. The combustion-chamber opening shall be separated from a fan plenum by an airtight separation without openings therein, except through an air lock at least 16 square feet in area, equipped with tight-fitting doors arranged to close automatically. A fan plenum access not exceeding 24 by 30 inches may be equipped with a tight-fitting panel or door.

(c) **Area Requirements.** The minimum unobstructed total area of the outside or return-air ducts or openings to a gravity-type warm-air furnace shall be not less than 7 square inches per 1000 Btu/h approved output rating or as indicated by the conditions of listing of the furnace.

The minimum unobstructed total area of the outside or return-air ducts or openings to a blower-type warm-air furnace shall be not less than 2 square inches per 1000 Btu/h approved output rating or bonnet capacity of the furnace.

The total area of the outside or return-air ducts or openings need not be larger than the minimum indicated by the conditions of listing of the furnace.

The minimum unobstructed total area of the outside or return-air ducts or openings to a heat pump shall be not less than 6 square inches per 1000 Btu/h nominal output rating or as indicated by the conditions of listings of the heat pump.

(d) **Dampers.** Volume dampers shall not be placed in the air inlet to a furnace in a manner which will reduce the required air to the furnace.

(e) **Ducts for Blower-type Warm-air Furnace.** Except as provided in Subsection (f) of this section, air for every fuel-burning blower-type warm-air furnace shall be conducted into the blower housing from outside the furnace space by continuous airtight ducts.

(f) **Prohibited Sources.** Outside or return air for a heating system shall not be taken from the following locations:

1. Closer than 10 feet from an appliance vent outlet, a vent opening or a plumbing drainage system or the discharge outlet of an exhaust fan, unless the outlet is 3 feet above the outside-air inlet.

2. Where it will pick up objectionable odors, fumes or flammable vapors; or where it is less than 10 feet above the surface of any abutting public way or driveway; or where it is in a horizontal position in a sidewalk, street, alley or driveway.

3. A hazardous or insanitary location or a refrigeration machinery room as defined in this code.

4. From an area the volume of which is less than 25 percent of the entire volume served by such system, unless there is a permanent opening to an area the volume of which is equal to 25 percent of the entire volume served. This permanent opening when used to provide return air to a warm-air furnace shall be of sufficient area to comply with Subsection (c) of this section.

> **EXCEPTION:** Such opening when used for a warm-air furnace in a dwelling unit may be reduced to no less than 50 percent of the required area, provided the balance of the required return air is taken from a room or hall having at least three doors leading to other rooms served by the furnace.

5. From a room or space having any fuel-burning appliances therein.

EXCEPTION: This shall not apply to:

1. Fireplaces, fireplace appliances, residential cooking appliances, direct vent appliances, enclosed furnaces and domestic- type clothes dryers installed within the room or space.

2. A gravity-type or listed vented wall furnace.

3. A blower-type system complying with the following requirements:

Where the return air is taken from a room or space having a volume exceeding 1 cubic foot for each 10 Btu/h fuel input rate of all fuel-burning appliances therein.

At least 75 percent of the supply air is discharged back into the same room or space.

Return-air inlet shall not be located within 10 feet of any appliance firebox or draft diverter in the same enclosed room or confined space.

6. A closet, bathroom, toilet room or kitchen.

(g) **Screen.** Required outside-air inlets shall be covered with screen having 1/4-inch openings.

EXCEPTION: An outside-air inlet serving a nonresidential portion of a building may be covered wth screen having openings larger than 1/4 inch but in no case larger than 1 inch.

(h) **Return-air Limitation.** Return air from one dwelling unit shall not be discharged into another dwelling unit through the heating system.

Air Supply

Sec. 707. (a) **Duct Size.** The minimum unobstructed total area of the supply-air ducts from a blower-type warm-air furnace shall be not less than 2 square inches per 1000 Btu/h approved output rating of the furnace, and the minimum unobstructed total area of the supply-air ducts from a gravity-type warm-air furnace shall be not less than 7 square inches per 1000 Btu/h approved output rating or as specified by the conditions of listing of the furnace. The total area of the supply-air ducts need not exceed the area of the furnace outlet plenum collar.

For the purpose of this section a volume damper, grille or register installed to control airflow shall not be considered an obstruction.

The minimum unobstructed total area of the supply-air ducts from a heat pump shall be not less than 6 square inches per 1000 Btu/h nominal output rating or as indicated by the conditions of the listing of the heat pump.

(b) **Surgical Operating Room.** Warm-air furnace duct openings serving a surgical operating room shall be at least 5 feet above the floor.

Attic Furnace

Sec. 708. Upright furnaces may be installed in an attic or furred space more than 5 feet in height, provided the required listings and furnace and duct clearances are observed.

Clearances of a warm-air attic furnace from combustibles shall be as specified in Section 504.

An attic or furred space in which a warm-air furnace is installed shall be accessible by an opening and passageway as large as the largest piece of the furnace and in no case less than 30 inches by 30 inches continuous from the opening to the furnace and its controls.

> **EXCEPTION:** The access opening into the space may be 22 inches by 30 inches, provided the largest piece of equipment can be removed through the opening.

The distance from the passageway access to furnace shall not exceed 20 feet measured along the center line of the passageway. The passageway shall be unobstructed and shall have continuous solid flooring not less than 24 inches wide from the entrance opening to the furnace.

A level working platform not less than 30 inches in depth shall be provided in front of the entire firebox side of the warm-air furnace, and if the furnace temperature-limit control, air filter, fuel-control valve, vent collar or air-handling unit is not serviceable from the firebox side of the furnace, a continuous floor not less than 24 inches in width shall be provided from the platform in front of the firebox side of the furnace to and in front of this equipment.

> **EXCEPTION:** A working platform need not be provided when the furnace can be serviced from the required access opening.

A permanent electric outlet and lighting fixture controlled by a switch located at the required passageway opening shall be provided at or near the furnace.

Warm-air Furnaces Located in Under-floor Spaces

Sec. 709. A warm-air furnace installed in the under-floor area of a building shall comply with the following requirements:

1. Clearance from combustibles shall be as specified in Section 504.

2. An access opening and passageway of a height and width sufficient to permit removal of the furnace, but in no case less than 30 inches by 30 inches, shall be provided to the working space in front of the furnace. The access opening to the passageway shall be through an opening in an exterior wall of the building or through a trap door within the building. The distance from the passageway access to the center line of the working space in front of the furnace burner shall not exceed 20 feet measured along the center line of the passageway.

3. A furnace supported from the ground shall rest on a concrete slab extending not less than 3 inches above the adjoining ground level.

4. The lowest portion of a suspended furnace shall have a clearance of at least 6 inches from the ground. Excavation necessary to install a furnace shall extend to a depth of 6 inches below and 12 inches on all sides of the furnace except the control side, which shall have 30 inches. If the depth of the excavation for either furnace or passageway exceeds 12 inches, walls of the excavation shall be lined with concrete or masonry extending 4 inches above the adjoining ground level. In floodplain areas the entire crawl space grade or height shall provide 12-inch clearance between the bottom of the furnace and the ground.

5. A permanent electric outlet and lighting fixture controlled by a switch located at the passageway opening shall be provided at or near the furnace.

Furnaces Installed on Roofs or Exterior Walls of Buildings

Sec. 710. (a) **General.** A furnace installed on a roof or exterior wall of a building shall comply with the requirements for roof and wall structures specified in the Building Code, and the equipment shall be listed or approved for such use.

(b) **Weather Protection.** Unless listed or designed for outside installation, a furnace on the roof of a building shall be enclosed in a penthouse complying with the requirements of the Building Code for roof structures or shall be completely enclosed in a weatherproof housing. The housing when constructed of metal shall be of galvanized steel not less than 0.024 inch (No. 24 U. S. Standard gage) or of aluminum not less than No. 22 B. & S. gage supported on a substantial metal frame. The housing shall be not larger than necessary to properly cover and provide a minimum 6-inch clearance around the appliance or appliances enclosed therein, including all controls and draft diverters.

(c) **Ventilation.** An enclosure or penthouse shall be provided with openings complying with the requirements of Chapter 6, together with means for proper ventilation of the furnace draft hood relief openings.

(d) **Clearance.** Clearance of the furnace from combustible construction shall be as specified in Section 504.

(e) **Platform.** A furnace located on a roof shall be installed on a substantial level platform. When the roof has a slope greater than 4 in 12, a level working platform at least 30 inches in depth shall be provided along the firebox and control sides of the furnace. Sides of a working platform facing the roof edge below shall be protected by a substantial railing 42 inches in height with vertical rails not more than 21 inches apart, except that parapets at least 24 inches in height may be utilized in lieu of rails or guards.

(f) **Catwalk.** On roofs having slopes greater than 4 in 12, a catwalk at least 16 inches in width with substantial cleats spaced not more than 16 inches apart shall be provided from the roof access to the working platform at the appliance.

(g) **Roof Access Scuttle.** Required working platforms, railings and catwalks may be omitted when access to the equipment is through a required roof scuttle and all of the following provisions are met:

1. The required scuttle is located immediately adjacent to the control side of the equipment unit.

2. Controls, filters, burners, fans and motors are accessible for service and repair within 2 feet of the edge of the equipment platform on the scuttle side.

3. The equipment platform is not more than 20 inches above the high side of the scuttle opening.

4. A substantial working platform not less than 30 inches by 30 inches shall be provided directly below the scuttle at a point not less than 30 inches or more than 32 inches below the high side of the scuttle opening.

5. Scuttles located on other than the roof incline side of the equipment unit shall have the hatch hinged on the low side of the scuttle. Hatches shall be equipped with means to ensure an opening radius of not less than 90 nor more than 100 degrees from the closed position. Hatches and hardware, when open, shall be capable of withstanding a 300-pound lateral force from the roof incline side.

6. Access to scuttles shall comply with Section 708.

(h) **Access.** Every furnace installed in or on an exterior wall of a building, which is designed so that the burners or controls must be serviced from outside the building, shall be readily accessible.

Furnaces located on the roof of a building shall be readily accessible.

> **EXCEPTIONS:** 1. Permanent exterior ladders providing roof access need not extend closer than 8 feet to the finish grade.
>
> 2. A portable ladder may be used for access for furnaces on the single-story portion of a Group M or R Occupancy.
>
> 3. Permanent ladders for equipment access need not be provided at parapets or walls less than 30 inches in height.

Permanent ladders providing roof access shall:

1. Have side railings which extend at least 30 inches above the roof edge or parapet wall.
2. Have landings less than 18 feet apart measured from the finished grade.
3. Be at least 14 inches in width.
4. Have rungs not more than 14 inches on center.
5. Have a minimum of $3^1/_2$-inch toe space.

Chapter 8

VENTED DECORATIVE APPLIANCES, FLOOR FURNACES, VENTED WALL FURNACES, UNIT HEATERS AND ROOM HEATERS

Scope

Sec. 801. In addition to the requirements of Chapter 5, vented decorative appliances, floor furnaces, vented wall furnaces, unit heaters and room heaters shall comply with the applicable requirements of this chapter.

General

Sec. 802. Vented decorative appliances, floor furnaces, vented wall furnaces, unit heaters and room heaters shall be of a type listed for vented use and shall be connected to a vent complying with Chapter 9, except as provided in Section 807.

Vented decorative appliances, floor furnaces, vented wall furnaces, unit heaters and room heaters shall be provided with combustion air complying with Chapter 6.

A vented decorative appliance, floor furnace, vented wall furnace, unit heater or room heater shall not be located in the following places:

1. In a surgical operating room.
2. In a hazardous location.
3. In a Group H, Division 1, 2 or 3 Occupancy.
4. In a room or space where an open flame is prohibited.
5. In Group H, Division 4 Occupancies, devices generating a spark or glow capable of igniting gasoline vapors shall not be installed or used within 18 inches of the floor.
6. In a Group H, Division 5 Occupancy, and Group B, Division 3 Occupancy, unless the appliance is located at least 8 feet above the floor.

Overhead heaters installed in aircraft storage or servicing areas of Group B, Division 3 Occupancies shall be at least 10 feet above the upper surface of wings or engine enclosures of the tallest aircraft which may be housed in the hangar. Overhead heaters shall be at least 8 feet above the floor of shops, offices and other sections of hangars communicating with aircraft storage or working areas.

Vented decorative appliances, floor furnaces, vented wall furnaces, unit heaters and room heaters shall be installed so as to minimize the probability of damage from an external source.

Vented Decorative Appliances

Sec. 803. In addition to the general requirements specified in Section 802, vented decorative appliances shall comply with the requirements specified for heating equipment and heating appliances of this code.

Approved gas logs may be installed in solid-fuel-burning fireplaces, provided:

1. The gas log is installed in accordance with the manufacturer's installation instructions.

2. If the fireplace is equipped with a damper, it shall be permanently blocked open to a sufficient amount to prevent spillage of combustion products into the room.

3. The minimum flue passageway shall be not less than 1 square inch per 2000 Btu/h input.

4. Gas logs when equipped with a pilot shall have a listed safety shutoff valve.

Floor Furnaces

Sec. 804. (a) **Placement.** In installations utilizing flat floor furnaces, at least 6 inches clearance from wall surfaces shall be maintained. Flat floor furnaces shall be located so as to provide at least 24 inches clear space on two adjoining sides of the installation. Wall-register-type floor furnaces shall be located at least 6 inches from inside wall corners.

> **EXCEPTION:** Replacement floor furnaces of the same or lesser Btu/h input rating may be installed in the same location as the replaced furnace when such replacement does not create an unsafe condition.

Doors shall be located so that no part swings within 12 inches of the grille openings of a floor furnace. Door stops and door closers shall not be relied upon to provide the required separation. Projections extending over floor furnaces shall be located at least 5 feet vertically above the warm-air grille.

Neither flat nor wall-register-type floor furnaces shall be located in the floor or wall of an aisle, foyer, corridor or exit other than in a dwelling unit.

Floor furnace locations shall be selected so that the burner assembly projects into unoccupied under-floor space.

(b) **Access.** An opening and passageway not less than 24 inches by 18 inches shall be provided to floor furnaces. Passageways shall be not more than 20 feet in length from the required access opening or from an under floor area having at least 30 inches height.

(c) **Installation.** Floor furnaces shall be supported independently of the furnace floor grille.

Floor furnaces shall be not closer than 6 inches to the ground.

> **EXCEPTION:** Where the lower 6-inch portion of such furnace is sealed by the manufacturer to prevent entrance of water, such clearance may be reduced to 2 inches.

When it is necessary to excavate to install a floor furnace, the excavation shall extend 30 inches beyond the control side of the floor furnace and 12 inches beyond the remaining sides and the back.

Excavations required by this subsection shall slope outward from the perimeter of the base of the excavation to the natural grade under that portion of the building at an angle not exceeding 45 degrees from horizontal.

Floor furnaces shall not be installed on a concrete slab on grade.

Vented Wall Furnaces

Sec. 805. (a) **Location.** Vented wall furnaces designed to be installed in a nominal 4-inch wall shall be not less than 6 inches from an inside room corner unless listed for lesser clearances.

> **EXCEPTION:** Replacement of vented wall furnaces of the same or lesser Btu/h input rating may be installed in the same location as the replaced furnace if it does not create an unsafe condition.

Vented wall furnaces shall be located so that a door cannot swing within 12 inches of an air inlet or air outlet of such furnace measured at right angles to the opening. Doorstops or door closers shall not be installed to obtain this clearance.

Except when specifically approved, vented wall furnaces shall be installed at least 18 inches below any structural projection. This requirement includes doors and windows which could project over the furnace.

(b) **Combustion Air.** Vented wall furnaces shall be provided with combustion air complying with Chapter 6.

> **EXCEPTION:** The required combustion air openings may be omitted to an area in which a vented wall furnace is installed, provided there is a permanent cased opening or archway through which a person may walk, opening into other rooms having a combined volume of 50 cubic feet per 1000 Btu/h input rating of such furnace.

(c) **Limitations.** Ducts shall not be attached to wall furnaces. Casing extensions or boots may be installed, if listed as part of the appliance.

Unit Heaters

Sec. 806. (a) **Suspended-type Unit Heaters.** Suspended-type unit heaters shall be installed as follows:

1. Safely and securely supported with hangers and brackets of noncombustible material.

2. With clearances from combustible material of at least 18 inches at the sides, 12 inches at the bottom, 6 inches above the top and 18 inches beyond the front and rear of the heater, except as provided in Subsections (c) and (d) of this section.

(b) **Floor-mounted-type Unit Heaters.** Floor-mounted-type unit heaters shall be installed as follows:

1. With clearances from combustible material as set forth in Table No. 5-A, except as provided in Subsections (c) and (d) of this section.

2. On combustible floors if listed for such installation.

(c) **Unit Heaters Listed for Reduced Clearances.** Unit heaters listed for reduced clearances may be installed at the clearances indicated on the required manufacturer's label.

(d) **Unit Heaters Listed for Greater Clearances.** Unit heaters listed for a greater clearance shall be installed to conform with the terms of listing and the manufacturer's installation instructions.

(e) **High-static Pressure-type Unit Heaters.** High-static pressure-type unit heaters with provisions for duct connections may be connected to ducts, provided:

1. The air inlets and air outlets are located in the same space as the unit heater.
2. Ducts and plenums shall conform with the requirements as specified in Chapter 10 of this code.

(f) **Unit Heaters Installed in Group B Occupancies.** Unit heaters installed in a Group B, Division 1 or 3 Occupancy shall obtain return air more than 4 feet above the floor.

Room Heaters

Sec. 807. (a) **Vented Freestanding.** Vented freestanding room heaters shall be installed with clearances from combustible material as set forth in Table No. 5-A.

> **EXCEPTION:** Heaters listed for reduced clearances may be installed at the clearances specified on the required manufacturer's label.

Vented freestanding room heaters shall not be located so that a door can swing within less than 12 inches of a warm-air outlet of the heater, measured at right angles to the outlet. Doorstops or door closers shall not be installed to obtain such clearance.

Vented freestanding room heaters shall be located at least 36 inches below any part of a structure projecting over the heater. This projection shall include doors or windows that could project over the heater.

Vented freestanding room heaters shall be safely and securely installed to prevent accidental displacement.

(b) **Vented Overhead.** Vented overhead room heaters shall be safely and securely supported with hangers and brackets of noncombustible material and shall be installed with clearances from combustible material as specified on the required manufacturer's label.

> **EXCEPTION:** Installation of overhead heaters in aircraft storage or servicing areas of Group B, Division 3 Occupancies shall comply with requirements of Section 802.

(c) **Unvented.** Unvented fuel-burning room heaters shall not be installed, used, maintained or permitted to exist in a Group I or R Occupancy nor shall an unvented heater be installed in any building, whether as a new or as a replacement installation, unless permitted by this section. This subsection shall not apply to portable oil-fired unvented heating appliances used as supplemental heating in Groups B and M Occupancies and regulated by the Fire Code.

(d) **Overhead Radiant Heaters.** Listed or approved unvented overhead room heaters may be installed in Group A, Division 2, 2.1, 3 or 4; Groups B, H, Division 4; Group H, Division 5, or Group M Occupancy, provided the installation conforms to all of the following requirements:

1. All portions of the heater are located at least 8 feet above the floor.
2. At least two unobstructed permanent openings are provided to the room or space containing such heaters. These openings shall open directly to the outside of

the building through the floor, roof or wall. The minimum combined total area of these openings shall be at least 1 square inch for each 1000 Btu/h input of the heater or heaters, with a minimum total area of 100 square inches. One half of the required openings shall be above the heater or heaters and one half shall be located below the heater or heaters.

> **EXCEPTION:** When approved by the building official, provisions may be made to exhaust the products of combustion to the exterior by mechanical means.

3. Heaters shall be safely and securely supported with hangers and brackets of noncombustible material and installed with clearances from combustible material as specified on the required manufacturer's label.

Chapter 9

VENTING OF APPLIANCES

General

Sec. 901. Appliances designed to be vented shall be connected to a venting system as specified in Section 902 and the venting system shall comply with the provisions of this chapter, except as provided in this section.

Venting systems shall consist of approved chimneys, Type B vents, Type BW vents, Type L vents, plastic pipe recommended by the manufacturer of listed condensing appliances for use with specified models, or a venting assembly which is an integral part of a listed appliance.

Venting systems shall be designed and constructed so as to develop a positive flow adequate to convey all combustion products to the outside atmosphere.

Venting systems may be designed in accordance with accepted engineering methods when the design method has been approved by the building official.

A venting system which is an integral part of the vented appliance and plastic pipe recommended by the manufacturer in installation instructions as suitable for use with listed condensing appliances shall be installed in accordance with the appliance listing, manufacturer's installation instructions and applicable requirements of this code.

Gas venting systems serving appliances equipped with draft hoods and appliances listed for use with Type B vents may be designed in accordance with tables in Appendix C, Chapter 9, when the design method has been approved by the building official.

Type of Venting Systems Required

Sec. 902. (a) **General.** The type of venting system required to serve various classifications of appliances shall be as set forth in Tables No. 9-A and No. 9-B.

(b) **Limitations.** Type B vents shall not be used for venting the following:

1. Appliances which may be converted readily to the use of solid or liquid fuels;

2. Combination gas-oil-burning appliances;

3. Appliances listed for use with chimneys only.

(c) **Vent Connector.** Connectors used for gas appliances having draft hoods and for listed conversion-burner-equipped appliances having draft hoods may be constructed of materials having resistance to corrosion and heat not less than that specified in Section 915 (c) or they may be of Type B or Type L vent material.

(d) **Solid Fuel.** Solid-fuel-burning appliances shall not be connected to a venting system which serves gas- or oil-burning appliances.

(e) **Plastic Venting Systems for Use with Listed Condensing Appliances.** Condensing appliances which cool flue gases nearly to the dewpoint within the appliance resulting in low vent gas temperatures may use plastic venting materials and vent configurations unsuitable for noncondensing appliances. Listed condensing appliances shall be considered properly vented when installed in accordance with the terms of listing and the manufacturer's installation instructions.

Installation and Construction Requirements

Sec. 903. (a) **General.** Factory-built chimneys, Type L vents, Type B gas vents or Type BW gas vents shall be installed in accordance with the manufacturer's installation instructions, the terms of listing and the applicable requirements of this code.

Metal chimneys shall be installed according to the applicable requirements of Section 914. For masonry chimneys, see Section 913.

(b) **Dampers.** Manually operated dampers shall not be placed in chimneys, vents or chimney or vent connectors of liquid- or gas-burning appliances. Fixed baffles on the appliance side of draft hoods and draft regulators shall not be classified as dampers.

Automatically operated vent damper devices shall be listed and installed in accordance with the terms of the listing. Electrically and mechanically operated vent damper devices shall be arranged to prevent firing of the burner unless the damper is opened to a safe position.

(c) **Unused Openings.** Unused openings in a venting system shall be closed or capped to the satisfaction of the building official.

Location and Support of Venting Systems Other than Masonry Chimneys

Sec. 904. A combustion products vent, vent connector, chimney or chimney connector shall not extend into or through an air duct or plenum.

EXCEPTION: A venting system may pass through a combustion air duct.

Portions of venting systems which extend through occupied spaces shall be enclosed to avoid personal contact with or damage to the installation.

The base of a vent which extends to the ground shall rest on a solid masonry or concrete base at least 2 inches in thickness. The base of a vent which does not extend to the ground and is not self-supporting shall rest on a firm metal or masonry support.

Appliances shall not be vented into a fireplace or into a chimney serving a fireplace.

Venting systems shall be adequately supported for the weight and the design of the material used.

Length—Pitch—Clearances

Sec. 905. (a) **Vent Offsets.** Except as provided in Sections 901 and 907, gravity vents shall extend in a generally vertical direction with offsets not exceeding 45 degrees, except that a gravity vent system having not more than one 60-degree offset may be allowed.

Vent offsets shall be supported for their weight and shall be installed to maintain proper clearance, to prevent physical damage and to prevent separation of the joints.

An angle greater than 45 degrees from the vertical is considered a horizontal run. The total horizontal run of a vent plus the horizontal vent connector shall not exceed 75 percent of the vertical height of the vent.

(b) **Rise.** A vent connector which is a part of a gravity-type venting system shall have a continuous rise of not less than 1/4 inch per foot of length measured from the appliance vent collar to the vent.

(c) **Clearance.** Single-wall metal vent connectors, when permitted to be used by Section 902, shall be provided with clearances from combustible material of not less than that set forth in Table No. 5-C.

Vent Termination

Sec. 906. (a) **General.** Vents shall extend above the roof surface, through a flashing, and terminate in a listed vent cap installed in accordance with its listing and the manufacturer's installation instructions.

(b) **Gravity-type.** Gravity-type venting systems, other than a Type BW gas-venting system or a venting system which is an integral part of a listed appliance shall terminate not less than 5 feet above the highest vent collar which it serves.

(c) **Wall Furnace.** Type BW gas vent serving a vented wall furnace shall terminate at least 12 feet in vertical height above the bottom of the furnace, except as provided in Section 907.

(d) **Type B or BW.** Type B or BW gas vent shall terminate as follows:

1. Gas-vent caps having an internal diameter greater than 12 inches shall terminate not less than 2 feet above the highest point where the vent passes through the roof and not less than 2 feet above or 10 feet away from any portion of a building which extends at an angle of more than 45 degrees upward from the horizontal.

2. Gas-vent caps having an internal diameter of 12 inches or less shall terminate at least 2 feet above or 8 feet away from any portion of a building which extends at an angle of more than 45 degrees upward from the horizontal.

Gas-vent caps having an internal diameter of 12 inches or less that are located 8 feet or more from a portion of a building which extends at an angle greater than 45 degrees upward from the horizontal may terminate in accordance with Figure No. 1, provided that in no case shall any discharge opening on the cap be less than 2 feet horizontally from the roof surface.

Roof Slope	Minimum Height from Roof to Lowest Discharge Opening, Feet-Inches
Flat to 7/12	1—0
Over 7/12 to 8/12	1—6
Over 8/12 to 9/12	2—0
Over 9/12 to 10/12	2—6
Over 10/12 to 11/12	3—3
Over 11/12 to 12/12	4—0
Over 12/12 to 14/12	5—0
Over 14/12 to 16/12	6—0
Over 16/12 to 18/12	7—0
Over 18/12 to 20/12	7—6
Over 20/12 to 21/12	8—0

FIGURE NO. 1

(e) **Type L.** Type L venting systems shall terminate not less than 2 feet above the highest point where the vent passes through the roof of the building and at least 2 feet higher than any portion of the building within 10 feet of the vent.

(f) **Vent Terminals.** Venting systems shall terminate not less than 4 feet below or 4 feet horizontally from, and not less than 1 foot above a door, an openable window or a gravity air inlet into a building.

> **EXCEPTION:** Vent terminals of direct vent appliances with inputs of 50,000 Btu/h or less shall be located at least 9 inches from an opening through which combustion products could enter a building. Appliances with inputs exceeding 50,000 Btu/h but not exceeding 65,000 Btu/h shall require 12-inch vent termination clearances. The bottom of the vent terminal and the air intake shall be located at least 12 inches above grade.

Venting systems shall terminate at least 3 feet above an outside- or makeup-air inlet located within 10 feet and at least 4 feet from a property line except a public way.

(g) **Outdoor Appliances with Integral Vents.** Appliances listed for outdoor installation incorporating integral venting means shall be considered as being properly vented when they are installed in accordance with their listings and the manufacturer's instructions. Venting systems shall terminate at least 4 feet below or 4 feet horizontally from, and at least 1 foot above a door, an openable window or a gravity-air inlet into building. Venting systems shall terminate not less than 3 feet above a forced-air inlet located within 10 feet and at least 4 feet from a property line, except a public way.

Vents for Wall Furnaces Requiring a Type BW Gas Vent

Sec. 907. In addition to other requirements specified in this chapter, gas-burning vented wall furnaces requiring a Type BW gas vent shall be vented to comply with the following requirements:

1. Type BW gas vents shall be attached to a solid header plate designed for the vented wall furnace installed. This attachment shall be made by a base plate furnished with the gas vent used.

2. The stud space in which a Type BW gas vent is installed shall be free of obstructions, except for fire-stop spacers that are required for multistory Type BW gas vents. All ceiling plates and floor plates through which the gas vent passes shall be cut flush with the adjacent wall studs.

3. Clearance of Type BW gas vent from any material shall be that space provided by the base plate, ceiling plate spacer straps and fire-stop spacers, furnished with the gas vent used. When Type BW gas vent is located in a stud space, care shall be exercised so that clearances provided by spacers are maintained after application of wall coverings and other parts of the construction. A sheet metal barrier shall be installed between a BW gas vent located in a stud space and wall covering constructed of perforated lath, metal lath or building paper.

4. Type BW gas vent listed only for single-story use shall be installed only in a single-story building or on the top story of a multistory building. Type BW gas vent listed for multistory use may be installed in single- or multistory buildings.

5. A stud space that contains a Type BW gas vent, which is serving a vented wall furnace installed in a single-story building or in the top story of a multistory building, shall be open to an attic space or to a ventilated roof flashing equipped with a storm collar.

> **EXCEPTION:** In lieu of a ventilated roof flashing, this stud space may be ventilated by providing an opening in the wall covering, within 12 inches of the upper portion of the stud space, opening into a room served by the wall furnace.

Where a Type BW gas vent extends into an attic space, a metal sleeve not less than .016 inch (No. 26 manufacturer's standard gage) steel, having the same area as the opening through the ceiling plate, shall extend around the gas vent from the top of the ceiling plate into the attic at least 12 inches or to a point 2 inches below the roof sheathing, whichever is the lesser. This sleeve shall be securely fixed in position.

> **EXCEPTION:** The metal sleeve will not be required if fire-stop spacers are required at the ceiling plate by Item 6 of this section.

6. The stud space in which a vented recessed wall furnace is installed shall be ventilated at the first ceiling plate level above the furnace by the ceiling plate spacer furnished with the gas vent used. Fire-stop spacers furnished with the gas vent used shall be installed at each subsequent ceiling plate through which the gas vent passes.

7. A suitable metal guard shall be installed at the floor line of each floor through which the gas vent passes to assure required clearance from combustible material and to prevent damage to the vent.

8. When a Type BW gas vent is installed in an existing building, the wall covering one side of the vent shall be completely open for installation and inspection.

9. Type BW gas vents shall extend from the header plate of the vented wall furnace to a point above the highest ceiling plate through which the vent passes, without offsets or crossovers therein. After a Type BW gas vent passes through the highest ceiling plate above the furnace which it serves, the vent system may be completed with Type B gas vent of the same manufacturer, and offsets or breakovers shall be limited to those specified in Section 905.

Size of Gravity Venting System

Sec. 908. Gravity venting systems shall have an internal cross-sectional area equivalent to the area of the vent collar on the appliance.

> **EXCEPTION:** Pressurized venting systems which are an integral part of a listed appliance employing plastic pipe are regulated under the fourth paragraph of Section 901 and Column IV of Table No. 9-B.

Gravity venting systems shall have an area of at least 7 square inches unless the venting system is an integral part of a listed appliance.

Multiple-appliance Venting Systems

Sec. 909. Two or more oil- or gas-burning appliances may be connected to a common venting system, or automatically controlled gas appliances may be vented into the same chimney serving liquid-fuel-fired appliances, provided: (a) the gas appliances are each equipped with a safety shutoff device, (b) each oil appliance is equipped with a primary safety control, and (c) the venting system is designed to meet the requirements of Section 901 of this code, or the venting system complies with the following requirements:

1. Appliances which are connected to a common venting system shall be located within the same story of the building, except designed vent systems as provided by Section 901.

2. Two or more connectors shall not enter a common venting system unless the inlets are offset in such a manner that no portion of an inlet is opposite the other inlets.

3. When two or more appliances are connected to one venting system, the venting system area shall be not less than the area of the largest vent connector plus 50 percent of the areas of the additional vent connectors.

4. Each vent connector of a multiple venting system shall have the greatest possible rise consistent with the headroom available between the draft hood outlet, the barometric damper or the flue collar and the point of interconnection to a manifold, to a common vent or to a chimney.

Existing Venting Systems

Sec. 910. An existing venting system shall not be connected to a replaced appliance unless the venting system complies with all the following requirements:

1. The venting system shall have been lawfully installed in compliance with the code in effect at the time of its installation and shall be in a safe condition.

2. The internal area of the venting system shall comply with Section 908 for a single-appliance venting system and Section 909 for multiple-appliance venting systems.

3. The venting system shall be connected to the appliance in a safe manner.

Draft Hoods

Sec. 911. An appliance draft hood shall be located in the same room or space as the combustion air opening of the appliance.

A draft hood shall be installed in the position for which it was designed and shall be located so that the draft hood relief opening is at least 6 inches from any surface other than the appliance it serves, measured in a direction 90 degrees to the plane of the relief opening. When a greater clearance is indicated by the appliance approval, as shown on the appliance label, the greater clearance shall be provided.

Types of Chimneys

Sec. 912. (a) **Factory-built Chimneys.** Factory-built chimneys shall be installed in accordance with the terms of their listing, the manufacturer's installation instructions and the applicable requirements of this code. Factory-built chimneys shall terminate as required for unlisted single-wall metal chimneys in Table No. 9-C.

(b) **Masonry Chimneys.** Masonry chimneys shall be constructed to meet the requirements of Section 913.

(c) **Metal Chimneys.** Metal chimneys shall be constructed to meet the requirements of Section 914.

Masonry Chimneys

Sec. 913. (a) **Design.** Masonry chimneys shall be designed, anchored, supported and reinforced as required in Chapters 23, 29 and 37 of the Building Code.

(b) **Gas Venting into Existing Masonry Chimneys.** Existing lined masonry chimneys and unlined chimneys with not more than one side exposed to the outside may be used to vent gas appliances, provided:

1. An approved liner shall be installed in an existing unlined masonry chimney when deemed necessary by the building official considering local problems of vent gas condensate.

2. The effective cross-sectional area is not more than four times the cross-sectional area of the vent and chimney connectors entering the chimney.

3. The effective area of the chimney when connected to more than one appliance shall be not less than the area of the largest vent or chimney connector plus 50 percent of the area of the additional vent or chimney connectors.

4. Automatically controlled gas appliances connected to a chimney which also serves equipment burning liquid fuel shall be equipped with an automatic pilot. A gas appliance vent connector and a chimney connector from an appliance burning liquid fuel may be connected into the same chimney through separate openings, provided the gas appliance is vented above the liquid fuel-burning appliance, or both may be connected through a single opening if joined by a suitable fitting located at the chimney.

5. The chimney passageway shall be examined to ascertain that it is clear and free of obstructions and shall be cleaned if previously used for venting solid- or liquid-fuel-burning appliances.

6. The vent or chimney connector shall enter the chimney at least 6 inches from the bottom of the chimney. The chimney shall be provided with a cleanout. If 6 inches are not available, a cleanout shall be provided by installing a capped tee in the vent connector next to the chimney.

Unlined chimneys with more than one side exposed to the outside shall be lined with an approved liner unless otherwise approved by the building official.

When inspection reveals that an existing chimney is not safe for the intended application, it shall be rebuilt to conform to chimney standards of the Building Code or replaced with an approved gas vent or factory-built chimney complying with Section 912 (a).

Metal Chimneys

Sec. 914. (a) **General.** 1. **Limitations.** Unlisted single-wall metal chimneys (smokestacks) shall not be installed within a dwelling unit of a Group R Occupancy.

Metal chimneys shall not be carried up inside ventilating ducts unless such ducts are constructed and installed as required by this code for chimneys and are used solely for exhaust of air from the room or space in which the appliances served by the metal chimneys are located.

2. **Design.** Metal chimneys shall have a minimum thickness of 0.127 inch (No. 10 manufacturer's standard gage) steel and shall be designed and constructed as specified in this chapter and Chapters 23 and 27 of the Building Code.

3. **Construction.** Unlisted metal chimneys shall be riveted or welded and, unless structurally self-supporting, shall be guyed securely or firmly anchored to or otherwise supported by the building or structure served thereby. All joints shall be liquid tight or of such a design that liquid will drain to the interior of the chimney.

4. **Lining.** Metal chimneys shall be lined as required by Table No. 9-C.

5. **Termination.** Metal chimneys shall terminate as required by Table No. 9-C.

6. **Clearance.** Clearance from combustible construction shall be in accordance with Table No. 9-C and the applicable requirements for each classification of chimney as required by this chapter.

When a metal chimney passes through a ceiling or roof constructed of combustible materials, it shall be protected by an approved ventilating thimble extending not less than 9 inches below and 9 inches above the ceiling or roof construction. Thimbles shall be of a size to provide a clearance on all sides of the chimney at least 18 inches, except that for chimneys of low-heat appliances the clearance may be reduced to at least 6 inches.

7. **Support.** Metal chimneys shall be supported on properly designed foundations of masonry or reinforced concrete or on noncombustible material having a fire-resistance rating of not less than three hours, provided such supports are independent of the building construction and the load is transferred to the ground.

8. **Enclosure required for interior chimneys.** Metal chimneys or parts thereof in a building exceeding one story in height shall be enclosed above the story in which the appliance served is located, in walls of noncombustible construction having a fire-resistive rating of not less than one hour if the building is less than four stories in height, and not less than two hours if the building is four stories or more in height, with a space on all sides between the chimney and the enclosing walls sufficient to render the entire chimney accessible for examination and repair. The enclosing walls shall be without openings.

> **EXCEPTION:** Doorways equipped with a fire assembly having a one-hour fire-resistive rating may be permitted at each floor level for inspection purposes.

(b) **Metal Chimneys for Building Heating and Industrial-type Low-heat Appliances.** When a metal chimney used for building heating and industrial-type low-heat appliances is located in the same story of a building as that in which the appliances connected thereto are located, it shall have a clearance of not less than 18 inches from any combustible material. Interior metal chimneys over 18 inches in diameter shall have a clearance of not less than 4 inches; those less than 18 inches in diameter shall have a clearance of at least 2 inches from noncombustible construction.

When a metal chimney serving only building heating and industrial-type or low-heat appliances passes through a roof constructed of combustible material, the roof shall be guarded by a ventilating thimble of galvanized steel or approved corrosion-resistant metal extending at least 9 inches below and 9 inches above the roof construction, and of a size to provide not less than 6-inch clearance on all sides of the chimney; or the combustible material in the roof construction shall be cut away so as to provide not less than 18-inch clearance on all sides of the chimney, with any material used to close up such opening entirely noncombustible.

(c) **Metal Chimneys for Medium-heat Appliances.** Metal chimneys for medium-heat appliances and producing flue gases having a temperature above 1000°F., measured at the entrance to the chimney, shall be lined with medium-duty firebrick which is in accordance with U.B.C. Standard No. 37-1, or the equivalent, laid in fireclay mortar. The lining shall be at least 2 1/2 inches thick for chimneys having a diameter or greatest cross-section dimension of 18 inches or less and shall have a thickness of not less than 4 1/2 inches laid on 4 1/2-inch bed for chimneys having a diameter or greatest cross-section dimension greater than 18 inches. The lining shall start 2 feet or more below the lowest chimney connector entrance and shall extend to a height of at least 25 feet above the highest chimney connector entrance.

Where a metal chimney serving a medium-heat appliance passes through a roof constructed of combustible material, the roof shall be guarded by a ventilating thimble of galvanized iron or approved corrosion-resistant metal extending not less than 9 inches below and 9 inches above the roof construction and of a size to provide not less than 18-inch clearance on all sides of the chimney.

Where a metal chimney used for medium-heat appliances is located in the same story of a building as that in which the appliances connected are located, it shall have a clearance of not less than 36 inches from any combustible material. Such interior metal chimneys over 18 inches in diameter shall have a clearance of not less than 4 inches, and those 18 inches or less in diameter a clearance of not less than 2 inches from noncombustible construction.

(d) **Metal Chimneys for High-heat Appliances.** Metal chimneys for high-heat appliances shall be lined with high-duty firebrick as specified in U.B.C. Standard No 37-1, or the equivalent, not less than 4 1/2 inches thick laid on the 4 1/2-inch bed in refractory mortar as specified in U.B.C. Standard No 37-1, or the equivalent. The lining shall start 2 feet or more below the lowest chimney connector entrance and shall extend to a height of at least 25 feet above the highest chimney connector entrance. Chimneys terminating 25 feet or less above a chimney connector entrance shall be lined to the top.

(e) **Metal Chimneys for Incinerators.** 1. **Residential-type incinerators.** Galvanized steel pipe not less than 0.129-inch (No. 10 galvanized-sheet gage number) or other equivalent noncombustible, fire- and corrosion-resistant material may be used for residential-type incinerators installed in locations such as open sheds, breezeways or carports, provided the pipe is exposed and readily examinable for its full length and clearance not less than 18 inches is maintained from combustible material. The pipe shall extend at least 3 feet above the highest point where it passes by or through a roof and at least 2 feet higher than any portion of a building within 10 feet. If the pipe passes through a roof constructed of combustible material, it shall be guarded by a ventilating thimble of galvanized sheet steel or approved corrosion-resistant noncombustible material extending not less than 9 inches below and 9 inches above the roof construction and of a size to provide not less than 6-inch clearance on all sides of the pipe; or the combustible material in the roof construction shall be cut away so as to provide not less than 18-inch clearance on all sides of the pipe, with any material used to close up such opening entirely noncombustible.

2. **Commercial and industrial-type incinerators.** Metal chimneys for commercial and industrial-type incinerators shall be lined with medium-duty firebrick as specified in U.B.C. Standard No. 37-1, or the equivalent, not less than 4 1/2 inches thick laid on the 4 1/2-inch bed in refractory mortar, medium duty as specified in U.B.C. Standard No. 37-1, or the equivalent. The lining shall start at the base of the chimney and extend continuously to the top.

Metal chimneys of commercial and industrial-type incinerators shall extend at least 3 feet above roofs measured from the highest point at which the metal chimney passes through the roof. In any case, the chimney shall extend at least 10 feet higher than any portion of a building within 25 feet.

Metal chimneys for commercial and industrial incinerators shall be installed to provide clearances as specified in Section 914 (c), Metal Chimneys for Medium-heat Appliances.

(f) **Spark Arrestors.** Chimneys serving incinerators shall terminate in a substantially constructed spark arrestor having an area not less than four times the net free area of the chimney it serves. Openings shall not permit the passage of a sphere having a diameter larger than 1/2 inch nor block the passage of a sphere having a diameter less than 3/8 inch. Spark arrestors shall be adequately supported and secured.

(g) **Enclosures.** Metal chimneys serving flue-fed, chute-fed, commercial or industrial-type incinerators, extending through any story of a building above that in which the incinerator is located, shall be enclosed in the upper stories within a continuous enclosure constructed of materials which are not combustible, such as masonry. The enclosure shall extend from the ceiling of the incinerator room to or through the roof so as to retain the integrity of the fire separations as required by applicable Building Code provisions. The enclosure shall have a fire-resistance rating of not less than one hour if the building is less than four stories in height, and not less than two hours if the building is four or more stories in height. All openings into the enclosing walls shall be protected with a self-closing fire assembly having a fire-resistive rating of not less than one and one-half hours.

Connectors

Sec. 915. (a) **General.** Connectors shall be used to connect fuel-burning appliances to a vertical chimney or vent unless the chimney or vent is attached directly to the appliance. Such connectors shall be installed within the space or area in which the appliance is located and shall be connected to a chimney or vent in such a manner as to maintain the clearance to combustibles as required in Table No. 5-C. Chimney connectors shall be attached to factory-built chimneys as required by the listing and the manufacturer's installation instructions.

> **EXCEPTION:** Listed appliances with integral venting systems such as direct vent appliances need not comply.

Connectors serving gravity-vent-type appliances shall not be connected to a venting system served by a power exhauster unless the connection is made on the negative pressure side of the power exhauster.

All connectors shall be as short and straight as possible.

An appliance shall be located as close as practical to the venting system.

Connectors shall not be concealed by building construction. Connectors made of Type B or Type L materials may be enclosed following inspection, provided the installation meets the provisions of Section 915 (b) 2 H.

Connectors shall not pass through an area or occupancy separation. Connectors may pass through other walls or partitions in accordance with the provisions of Section 915 (b) 2 F.

Single-wall metal pipe used as a connector shall not originate in an unoccupied attic or concealed space and shall not pass through an attic, inside wall or concealed space.

When the connector used for a gas appliance having a draft hood must be located or pass through a crawl space or other cold area, that portion of the connector shall be listed Type B or Type L vent material or be provided with equivalent means of insulation.

Connectors shall be installed so as to avoid sharp turns or other construction features which would create excessive resistance to the flow of flue gases. No device which will obstruct the free flow of flue gases shall be installed in a connector. This shall not be construed to prohibit the use of devices specifically listed or approved for installation in a connector, such as heat reclaimers, draft regulators and safety controls.

Connectors shall be securely supported and joints fastened with sheet metal screws, rivets or other approved means. At the point of connection of the single-wall connector to the double-wall gas vent, three sheet metal screws or rivets may be used as an approved means.

Manually operated dampers shall not be placed in connectors of stoker-fired, liquid- or gas-burning appliances. Fixed baffles on the appliance side of draft hoods and draft regulators shall not be classified as dampers. Automatically operated dampers shall be listed and installed in accordance with the terms of the listing and arranged to prevent the initiation or increase of firing unless the damper is opened to a safe position.

Connectors shall be adequately supported for the design and weight of the materials employed to maintain proper clearances, to prevent physical damage and to prevent separation of the joints.

(b) **Chimney Connectors.** 1. **Materials.** A. **General.** Chimney connectors shall be constructed of single-wall metal conforming with subparagraphs B and C of this subsection, of Type L vent material or of other materials approved for the use intended. Chimney connectors used for listed gas appliances with draft hoods may be installed in accordance with the provisions of Section 915 (c).

B. **Residential and low-heat appliances.** If serving residential building-heating appliances and low-heat appliances, chimney connectors made of single-wall steel pipe shall be of at least the thickness indicated.

DIAMETER OF CONNECTOR (In Inches)	MINIMUM THICKNESS (In Inches)	(GALVANIZED SHEET GAGE NO.)
5 or less	0.013	(28)
Over 5 to 9	0.019	(26)
Over 9 to 12	0.030	(22)
Over 12 to 16	0.036	(20)
Over 16	0.058	(16)

Breeching for medium-heat and high-heat appliances shall be fabricated of black hot-rolled steel with welded seams and shall be of at least the following thickness:

DIAMETER OF CONNECTOR (In Inches)	MINIMUM THICKNESS (In Inches)	(MANUFACTURER'S STANDARD GAGE NO.)
12 or less	0.044	(18)
Over 12 to 24	0.055	(16)
Over 24 to 36	0.068	(14)
Over 36 to 60	0.097	(12)
Over 60	0.127	(10)

End joints of breechings may be welded, lapped, bolted or made with companion end flanges. Long breechings shall be provided with expansion joints.

C. **Medium-heat appliances and industrial incinerators.** Metal connectors for medium-heat appliances and industrial incinerators shall be lined with firebrick not less than 2¼ inches thick when the appliance flue collar is not larger than 18 inches in diameter or greatest dimension, and 4½ inches thick when the flue collar is larger than 18 inches in diameter. Firebrick shall be laid in fireclay. All such connectors shall maintain a free area equal in size to the flue collar.

D. **High-heat appliances.** Metal connectors for high-heat appliances shall be lined with high-duty firebrick having a thickness of at least 4½ inches laid on the 4½-inch bed in fireclay mortar.

2. **Installation.** A. **Sizing.** The connector, for its entire length, shall be not smaller than the flue collar of the appliance unless otherwise recommended by the appliance, chimney or vent manufacturer.

Two or more chimney connectors shall not be joined unless the common connector, the manifold and the chimney are sized properly to serve the appliances connected thereto and adequate draft is available to remove all products of combustion to the outdoors.

B. **Clearance.** Single-wall metal connectors shall be installed with clearance to combustibles as set forth in Table No. 5-C.

C. **Draft regulators.** A draft regulator shall be installed in the connector serving a liquid-fuel-burning appliance unless the appliance is approved for use without a draft regulator.

A draft regulator may be installed in the connector serving a listed gas incinerator when recommended by the incinerator manufacturer. Draft regulators shall be installed in accordance with the installation instructions accompanying the incinerator.

A draft regulator, when used, shall be installed in the same room or enclosure as the appliance in such a manner that no difference in pressure between air in the vicinity of the regulator and the combustion air will be permitted.

D. **Pitch.** Chimney connectors shall have a rise of not less than 1/4 inch to the foot of run.

E. **Entering masonry chimneys.** A connector entering a masonry chimney shall extend through the wall to the inner face of the liner, but not beyond, and shall be firmly cemented to masonry. A thimble may be used to facilitate removal of the connector for cleaning, in which case the thimble shall be permanently cemented in place with high-temperature cement. The chimney connector shall enter the chimney not less than 6 inches from the bottom of the chimney. The chimney shall be provided with a cleanout. If 6 inches are not available, a cleanout shall be provided by installing a capped tee in the connector next to the chimney.

F. **Passage through walls or partitions.** The connector of a medium- or high-heat appliance as classified in Table No. 9-A shall not pass through any wall or partition constructed of combustible material.

Connectors for listed gas appliances with draft hoods, except incinerators and oil appliances listed for Type L vents, may pass through walls or partitions constructed of combustible materials if:

(i) Made of Type B or Type L material and installed with at least the listed clearances to combustible material.

(ii) Made of single-wall metal pipe and guarded by a ventilated thimble at least 4 inches larger in diameter than the vent connector.

Connectors for residential-type appliances may pass through walls or partitions constructed of combustible material to reach a masonry chimney if:

(i) The connector is listed for wall pass through and installed according to the listing.

(ii) The connector is put through a device listed for wall pass through.

(iii) The connector is 10 inches or less in diameter and is installed according to one of the methods specified in Table No. 9-D. Concealed metal parts of the pass-through system in contact with flue gases shall be of stainless steel or equivalent material that resists corrosion, softening or cracking up to 1,800°F.

In lieu of thimbles or other wall pass-through systems, combustible material in the wall or partition shall be cut away from the connector a sufficient distance to provide the clearance required from the connector. A material used to close up the openings shall be noncombustible material conforming to part 1 of the definition for "noncombustible" in Section 416.

G. **Length.** A connector shall be as short and straight as possible. The appliance shall be located as close as practicable to the chimney. The horizontal run of an uninsulated connector to a natural draft chimney shall be not more than 75 percent of the height of the vertical portion of the chimney above the connector, unless part of an engineered system.

The horizontal run of an insulated connector to a natural draft chimney serving a single fuel-fired appliance shall be not more than 100 percent of the height of the vertical portion of the chimney above the connector, unless part of an engineered system. The horizontal length, design and construction of combined connectors, or connectors to a manifold joining two or more appliances to a chimney, shall be determined in accordance with approved engineering methods.

H. **Access.** The entire length of a connector shall be accessible for inspection, cleaning and replacement, unless listed materials are used and approval has been obtained from the building official.

I. **Fireplace connection.** A chimney connector shall not be connected to a chimney flue serving a fireplace unless the fireplace opening is sealed or the chimney flue which vents the fireplace is permanently sealed below the connection.

(c) **Vent Connectors.** 1. **Materials.** Vent connectors used for gas appliances having draft hoods, for listed conversion-burner-equipped appliances having draft hoods and for other gas appliance(s) listed for use with Type B venting systems may be constructed of Type B or Type L vent material or of noncombustible corrosion-resistant material capable of withstanding the flue gas temperatures produced by the appliance, such as 0.016-inch (No. 28 galvanized sheet gage) steel, No. 26 B. & S. gage copper or No. 24 B. & S. gage aluminum.

2. **Installation.** A. **Size.** Vent connectors shall be sized in accordance with the requirements of Subsection (b) 2 A.

B. **Clearance.** Single-wall metal vent connectors, where permitted to be used by Section 902, shall be provided with clearances from combustible material of not less than that set forth in Table No. 5-C.

> **EXCEPTION:** A lesser clearance is acceptable if protection is provided according to the requirements of Tables No. 5-A and No. 5-B of Chapter 5 of this code.

C. **Length.** The maximum permissible length of a vent connector shall be in accordance with Subsection (b) 2 G.

D. **Pitch.** Vent connectors shall be installed without any downward pitch from the appliance and without any dips or sags. Vent connectors shall be pitched upwards from the appliance at least 1/4 inch per foot.

E. **Access.** The entire length of vent connectors shall be accessible for inspection, cleaning and replacement, unless listed materials are used and approval has been obtained from the building official.

F. **Limited passage through walls or partitions.** The passage of vent connectors through walls or partitions shall be limited to the conditions specified in Subsection (b) 2 F.

G. **Two or more appliances connected to a single vent.** Two or more vent connectors shall not be joined unless the common connector, the manifold and the vent are sized properly to serve the appliances connected thereto and adequate draft is available to remove all products of combustion to the outdoors.

Each vent connector of a multiple venting system shall have the greatest possible rise consistent with the headroom available between the draft hood outlet or the flue collar and the point of interconnection to a manifold or to a common vent.

Mechanical Draft Systems

Sec. 916. (a) **Forced or Induced Draft Systems.** Appliances, except incinerators, requiring venting also may be vented by means of mechanical draft systems of either forced or induced draft design.

(b) **Positive Pressure Systems.** Forced draft systems and all portions of induced draft systems under positive static pressure during operation shall be designed and installed so as to be gastight or as to prevent leakage of combustion products into a building.

(c) **Interconnected Systems.** Vent connectors serving gas appliances vented by natural draft shall not be connected into any portion of a mechanical draft system operating under positive pressure.

(d) **Interlock Controls.** When a forced-draft or induced-draft system is employed, provision shall be made to prevent the flow of gas to the main burner when the draft system is not performing so as to satisfy the operating requirements of the appliance for safe performance.

(e) **Exit Terminals.** The exit terminals of forced-draft and induced-draft systems shall be located not less than 12 inches from any opening through which combustion products could enter the building, nor less than 2 feet from an adjoining building, and not less than 7 feet above grade when located adjacent to public walkways.

Venting through Ventilating Hoods and Exhaust Systems

Sec. 917. (a) **Commercial Applications.** Ventilating hoods and exhaust systems may be used to vent gas-burning appliances installed in commercial applications.

(b) **Dampers.** When automatically operated appliances such as water heaters are vented through natural draft ventilating hoods, dampers shall not be installed in the ventilating system. When the ventilating hood or exhaust system is equipped with power means of exhaust, the appliance control system shall be interlocked so as to permit appliance operation only when the power means of exhaust is in operation.

TABLE NO. 9-A—CHIMNEY SELECTION CHART

CHIMNEYS FOR RESIDENTIAL APPLIANCES	CHIMNEYS FOR LOW-HEAT APPLIANCES		CHIMNEYS FOR MEDIUM-HEAT APPLIANCES	CHIMNEYS FOR HIGH-HEAT APPLIANCES
	Building-Heating Appliances	Industrial-Type Low-Heat Appliances		
1. Factory-built (Residential) 2. Masonry (Residential) 3. Metal (Residential)	1. Factory-built (low-heat) 2. Masonry (low-heat type) 3. Metal (smokestack)	1. Factory-built (industrial low-heat type) 2. Masonry (low-heat type) 3. Metal (smokestack)	1. Factory-built (medium-heat type) 2. Masonry (medium-heat type) 3. Metal (smokestack)	1. Masonry (high-heat type) 2. Metal (smokestack)
TYPES OF APPLIANCES TO BE USED WITH EACH TYPE CHIMNEY				
COLUMN I	**COLUMN II**	**COLUMN III**	**COLUMN IV**	**COLUMN V**
A. Residential-type appliances, such as: 1. Ranges 2. Warm-air furnaces 3. Water heaters 4. Hot-water-heating boilers 5. Low-pressure steam-heating boilers (not over 15 psig) 6. Domestic incinerators 7. Floor furnaces 8. Wall furnaces 9. Room heaters 10. Fireplace stoves 11. Closed-combustion-type solid-fuel-burning stoves or room heaters[1]	A. All appliances shown in Column I B. Nonresidential-type building-heating appliances for heating a total volume of space exceeding 25,000 cubic feet C. Steam boilers operating at not over 1,000°F. flue gas temperature; pressing machine boilers	All appliances shown in Columns I and II, and appliances such as: 1. Annealing baths for hard glass (fats, paraffin, salts, or metals) 2. Bake ovens (in bakeries) 3. Boiling vats, for wood fibre, straw, lignin, etc. 4. Candy furnaces 5. Coffee roasting ovens 6. Core ovens 7. Cruller furnaces 8. Feed drying ovens 9. Fertilizer drying ovens 10. Fireplaces, other than residential type 11. Forge furnaces (solid fuel) 12. Gypsum kilns 13. Hardening furnaces (below dark red)	All appliances shown in Columns I, II and III, and appliances such as: 1. Alabaster gypsum kilns 2. Annealing furnaces (glass or metal) 3. Charcoal furnaces 4. Cold stirring furnaces 5. Feed driers (direct-fire-heated) 6. Fertilizer driers (direct-fire-heated) 7. Galvanizing furnaces 8. Gas producers 9. Hardening furnaces (cherry to pale red) 10. Incinerators, commercial and industrial-type 11. Lehrs and glory holes 12. Lime kilns 13. Linseed-oil-boiling furnaces	All appliances shown in Columns I, II, III and IV, and appliances such as: 1. Bessemer retorts 2. Billet and bloom furnaces 3. Blast furnaces 4. Bone calcining furnaces 5. Brass furnaces 6. Carbon point furnaces 7. Cement brick and tile kilns 8. Ceramic kilns 9. Coal and water gas retorts 10. Cupolas 11. Earthenware kilns 12. Glass blow furnaces 13. Glass furnaces (smelting) 14. Glass kilns

B. Fireplaces		14. Hot-air engine furnaces 15. Ladle-drying furnaces 16. Lead-melting furnaces 17. Nickel plate (drying) furnaces 18. Paraffin furnaces 19. Recuperative furnaces (spent materials) 20. Rendering furnaces 21. Restaurant-type cooking appliances using solid or liquid fuel 22. Rosin-melting furnaces 23. Stereotype furnaces 24. Sulphur furnaces 25. Tripoli kilns (clay, coke and gypsum) 26. Type foundry furnaces 27. Wood-drying furnaces 28. Wood-impregnating furnaces 29. Zinc-amalgamating furnaces	14. Porcelain biscuit kilns 15. Pulp driers (direct-fire-heated) 16. Steam boilers operating at over 1,000°F. flue gas temperature 17. Water-glass kiln 18. Wood-distilling furnaces 19. Wood-gas retorts	15. Open hearth furnaces 16. Ore-roasting furnaces 17. Porcelain-baking and glazing kilns 18. Pot-arches 19. Puddling furnaces 20. Regenerative furnaces 21. Reverberatory furnaces 22. Stacks, carburetor or superheating furnaces (in water-gas works) 23. Vitreous enameling ovens (ferrous metals) 24. Wood-carbonizing furnaces

[1] When these appliances are vented with a factory-built chimney, the chimney shall be a listed Type HT chimney.

TABLE NO. 9-B—VENT SELECTION CHART

COLUMN I TYPE B, GAS Round or Oval	COLUMN II TYPE BW GAS	COLUMN III TYPE L	COLUMN IV PLASTIC PIPE
All listed gas appliances with draft hoods such as: 1. Central furnaces 2. Floor furnaces 3. Heating boilers 4. Ranges and ovens 5. Recessed wall furnaces (above wall section) 6. Room and unit heaters 7. Water heaters	1. Gas-burning wall heaters listed for use with Type BW vents	1. Oil-burning appliances listed for use with Type L vents 2. Gas appliances as shown in first column	1. Condensing appliances listed for use with a specific plastic pipe recommended and identified in the manufacturer's installation instructions.

TABLE NO. 9-C—CONSTRUCTION, CLEARANCE AND TERMINATION REQUIREMENTS FOR UNLISTED SINGLE-WALL METAL CHIMNEYS

CHIMNEYS SERVING	MINIMUM THICKNESS		TERMINATION				CLEARANCE			
				ABOVE ANY PART OF BUILDING WITHIN			COMBUSTIBLE CONSTRUCTION		NONCOMBUSTIBLE CONSTRUCTION	
	WALL	LINING	ABOVE ROOF OPENING	10′	25′	50′	INTERIOR INST.	EXTERIOR INST.	INTERIOR INST.	EXTERIOR INST.
Building-heating and industrial-type low-heat appliances (1000°F. operating-1400°F. temp. maximum)[1]	0.127″ (Mfrs. Std. 10 ga.)	None	3′	2′			18″	6″	Up to 18″ diameter, 2″ Over 18″ diameter, 4″	
Medium-heat industrial-type appliances (2000°F. maximum)[1,3]	0.127″ (Mfrs. Std. 10 ga.)	Up to 18″ dia.—2½″ Over 18″ 4½″ on 4½″ bed	10′		10′		36″	24″		

(Continued)

TABLE NO. 9-C—CONSTRUCTION, CLEARANCE AND TERMINATION REQUIREMENTS FOR UNLISTED SINGLE-WALL METAL CHIMNEYS—(Continued)

CHIMNEYS SERVING	MINIMUM THICKNESS		TERMINATION				CLEARANCE			
				ABOVE ANY PART OF BUILDING WITHIN			COMBUSTIBLE CONSTRUCTION		INCOMBUSTIBLE CONSTRUCTION	
	WALL	LINING	ABOVE ROOF OPENING	10′	25′	50′	INTERIOR INST.	EXTERIOR INST.	INTERIOR INST.	EXTERIOR INST.
High-heat industrial-type appliances (Over 2000°F.)[1,2]	0.127$in (Mfrs. Std. 10 ga.)	4½″ laid on 4½″ bed	20′			20′	See Footnote 4			
Residential-type incinerator[4]	0.127″ (Mfrs. Std. 10 ga.	None	3′	2′			Not permitted	18″	Not permitted	4″
Chute-fed, flue-fed commerical or industrial-type incinerators[2,5]	0.127″ (Mfrs. Std. 10 ga.)	4½″ laid on 4½″ bed	3′ above sloping roof or 8′ above flat roof		10′		36″	24″	Up to 18″ diameter, 2″ Over 18″ diameter, 4″	

[1] See Table No. 9-A for types of appliances to be used with each type of chimney.

[2] Lining shall extend from bottom to top of chimney.

[3] Lining shall extend from 24 inches below connector to 24 feet above.

[4] Clearance shall be as specified by the design engineer and shall have sufficient clearance from buildings and structures to avoid overheating combustible materials (maximum 160°F.).

[5] Spark arrestors shall be provided in accordance with Subsection 914 (f).

TABLE NO. 9-D—CHIMNEY CONNECTOR SYSTEMS AND CLEARANCES FROM ROOM WALL COMBUSTIBLES FOR RESIDENTIAL HEATING APPLIANCES

System A (12-inch clearance)	A 3½-inch-thick brick wall shall be framed into the combustible wall. A ⅝-inch-thick fire clay liner shall be firmly cemented in the center of the brick wall maintaining a 12-inch clearance to combustibles. The clay liner shall run from the outer surface of the bricks to the inner surface of the chimney liner, but it shall not protrude into the chimney liner.
System B (9-inch clearance)	A listed solid insulated factory-built chimney section (1-inch insulation) the same inside diameter as the connector shall be used. Sheet metal supports cut to maintain a 9-inch clearance to combustibles shall be fastened to the wall surface and to the chimney section. Fasteners shall not penetrate the chimney flue liner. The chimney length shall be flush with the masonry chimney liner and sealed to the masonry with water-insoluble refractory cement. Chimney manufacturer's parts shall be used to securely fasten the chimney connector to the chimney section.
System C (6-inch clearance)	A sheet metal (minimum 24 gage) ventilated thimble having two, one-inch air channels shall be used with a sheet steel chimney connector (minimum 24 gage). Sheet steel supports (minimum 24 gage) shall be cut to maintain a 6-inch clearance between the thimble and combustibles. One side of the support shall be fastened to the wall on all sides. Glass fiber insulation shall fill the 6-inch space between the thimble and the supports. The chimney section shall be secured to the support. Fasteners used shall not penetrate the liner of the chimney section.
System D (2-inch clearance)	A listed solid insulated factory-built chimney section (1-inch insulation) with a diameter 2 inches larger than the chimney connector shall be used with a sheet steel chimney connector (minimum 24 gage). Sheet metal supports shall be positioned to maintain a 2-inch clearance to combustibles and to hold the chimney connector to assure that a 1-inch air space surrounds it as it passes through the chimney section. The steel support shall be fastened to the wall on all sides and the chimney section shall be fastened to the supports. Fasteners used shall not penetrate the liner of the chimney section.

Requirements for systems in Table No. 9-D:

1. Insulation material used as a part of a wall pass through shall be noncombustible and shall have a thermal conductivity of 1.0 Btu-in./ft.^{2} °F. or less.
2. All clearances and thicknesses are minimums.
3. Materials used to close up openings for the connector shall be noncombustible.
4. Connectors for all systems except System B shall extend through the wall pass-through system to the inner face of the flue liner.

Chapter 10
DUCTS

Scope

Sec. 1001. Ducts and plenums which are portions of a heating, cooling, absorption or evaporative cooling system shall comply with the requirements of this chapter.

Material

Sec. 1002. (a) **General.** Supply air, return air and outside air for heating, cooling or evaporative cooling systems shall be conducted through duct systems constructed of metal as set forth in Tables Nos. 10-A, 10-B and 10-C; metal ducts complying with U.M.C. Standard No. 10-2 with prior approval; or factory-made air ducts complying with U.M.C. Standard No. 10-1. Ducts, plenums and fittings may be constructed of asbestos cement, concrete, clay or ceramics when installed in the ground or in a concrete slab, provided the joints are tightly sealed.

Corridors shall not be used to convey air to or from rooms if the corridor is required to be of fire-resistive construction by Section 3305 of the Building Code.

Concealed building spaces or independent construction within buildings may be used as ducts or plenums.

When gypsum products are exposed in ducts or plenums, the air temperature shall be restricted to a range from 50°F. to 125°F. and moisture content shall be controlled so that the material is not adversely affected. Gypsum products shall not be exposed in ducts serving evaporative coolers.

Venting systems and exhaust ducts shall not extend into or through ducts or plenums.

(b) **Combustibles within Ducts or Plenums.** Materials exposed within ducts or plenums shall have a flame-spread index of not more than 25 and a smoke-developed rating of not more than 50 when tested in accordance with the test for Surface Burning Characteristics of Building Materials, U.B.C. Standard No. 42-1.

EXCEPTIONS: 1. Return-air and outside-air ducts, plenums or concealed spaces which serve a dwelling unit may be of combustible construction.

2. Air filters serving a dwelling unit.

3. Air filters listed by an approved testing agency as complying with reference standards included in Appendix C.

4. Air filters used as water evaporation medium in an evaporative cooler.

5. Charcoal filters when protected with an approved fire suppression system.

6. Electrical wiring in plenums shall comply with the Electrical Code. Flame propagation and smoke production characteristics of exposed electric cables installed in concealed space used as air plenums shall:

A. Exhibit a flame travel of 5 feet or less, and

B. Produce smoke having an average optical density not greater than 0.15 and having a peak optical density of 0.5 or less when tested in accordance with U.M.C. Standard No. 10-3.

C. Wiring meeting these requirements shall be listed and labeled as plenum cable as required by the Electrical Code.

7. Nonmetallic fire sprinkler piping in plenums shall be listed and shall meet the following requirements:

A. Exhibit flame travel of 5 feet or less, and

B. Produce smoke having an average optical density not greater than 0.15 and having a peak optical density of 0.5 or less when tested in accordance with U.M.C. Standard No. 10-3.

(b) **Factory-made Air Ducts.** Factory-made air ducts shall be approved for the use intended or shall conform to the requirements of U.M.C. Standard No. 10-1. Each portion of a factory-made air duct system shall be identified by the manufacturer with a label or other suitable identification indicating compliance with U.M.C. Standard No. 10-1 and its class designation. These ducts shall be listed and shall be installed in accordance with the terms of their listing, and the requirements of U.M.C. Standard No. 10-5.

(c) **Joints and Seams of Ducts.** Joints of duct systems shall be made substantially airtight by means of tapes, mastics, gasketing or other means.

Crimp joints for residential round ducts shall have a contact lap of at least 1 1/2 inch and shall be mechanically fastened by means of at least three sheet-metal screws equally spaced around the joint, or an equivalent fastening method.

Joints and seams for 0.016-inch (No. 28 gage) and 0.013-inch (No. 30 gage) residential rectangular ducts shall be as specified in Table No. 10-A for 0.019-inch (No. 26 gage) material.

Joints and seams for rectangular duct systems shall be as specified in Table No. 10-A.

Joints and seams for flat oval ducts and round ducts in other than single dwelling units shall be as specified in Table No. 10-B.

Joints and seams and all reinforcements for factory-made air ducts and plenums shall meet with the conditions of prior approval in accordance with the installation instructions that shall accompany the product.

(d) **Metal.** Every duct, plenum or fitting of metal shall comply with Table No. 10-A or Table No. 10-B.

EXCEPTIONS: 1. Ducts, plenums and fittings for systems serving single dwelling units may comply with Table No. 10-C.

2. Duct systems complying with U.M.C. Standard No. 10-1.

(e) **Tin.** Existing tin ducts may be used when cooling coils are added to a heating system, provided the first 10 feet of the duct or plenum measured from the cooling coil discharge are constructed of metal of the gage thickness set forth in Table No. 10-A, No. 10-B or No. 10-C of this chapter or are of approved material and construction. Tin ducts completely enclosed in inaccessible concealed areas need not be replaced. All accessible ducts shall be insulated to comply with Table No. 10-D of this chapter. For the purpose of this subsection, ducts shall be considered accessible where the access space is 30 inches or greater in height.

(f) **Vibration Isolators.** Vibration isolators installed between mechanical equipment and metal ducts (or casings) shall be made of an approved material and shall not exceed 10 inches in length.

Quality of Material

Sec. 1003. Galvanized steel shall be of lock-forming quality with a minimum coating of 1.25 ounces of zinc per square foot conforming to the requirements of U.M.C. Standard No. 4-2.

Installation of Ducts

Sec. 1004. (a) **Metal Ducts.** Ducts shall be securely fastened in place at each change of direction and as set forth in Table No. 10-E. Vertical rectangular ducts and vertical round ducts shall be supported as set forth in Table No. 10-E, Part I. Riser ducts shall be held in place by means of metal straps or angles and channels to secure the riser to the structure.

Metal ducts shall be installed with at least 4 inches separation from earth. Metal ducts when installed in or under concrete slab shall be encased in at least 2 inches of concrete.

Supports for rectangular ducts as set forth in Table No. 10-E when suspended from above shall be installed on two opposite sides of each duct and shall be riveted, bolted or metal screwed to each side of the duct at not more than the intervals specified.

Horizontal round ducts 40 inches or less in diameter when suspended from above shall be supported at intervals not more than as set forth in Table No. 10-E with one hanger installed to comply with the requirements listed below:

1. Ducts shall be equipped with tight-fitting circular bands extending around the entire perimeter of the duct at each specified support interval.

2. Circular bands shall be not less than 1 inch wide nor less than equivalent to the gage of the duct material it supports.

> **EXCEPTION:** Ducts 10 inches and less in diameter may be supported by No. 18 gage galvanized steel wire.

3. Each circular band shall be provided with a suitable means of connecting to the suspending support.

4. Ducts shall be braced and guyed to prevent lateral or horizontal swing.

(b) **Factory-made Air Ducts.** Approved Class 0 or Class 1 factory-made air ducts may be installed in any occupancy covered by this code. Approved Class 2 air ducts may be installed only in dwellings or apartment houses where the duct system serves not more than one dwelling unit.

Factory-made air ducts shall not be used for vertical risers in air-duct systems serving more than two stories. Such ducts shall not penetrate construction where fire dampers are required.

Factory-made air ducts shall be installed with at least 4 inches of separation from earth, except when installed as a liner inside of concrete, tile or metal pipe; they shall be protected from physical damage.

Class 2 air ducts shall be installed with at least 3 feet of separation from a heat exchanger.

The temperature of the air to be conveyed in any of these classes of ducts shall be less than 251°F.

(c) **Protection of Ducts.** Ducts installed in locations where they are exposed to mechanical damage by vehicles or from other causes shall be protected by approved barriers.

(d) **Support of Ducts.** Installers shall furnish the manufacturer's field fabrication and installation instructions to building officials.

In the absence of specific supporting materials and spacing, approved factory-made air ducts may be installed as set forth in Table No. 10-F.

Insulation of Ducts

Sec. 1005. Supply- and return-air ducts and plenums of a heating or cooling system shall be insulated with not less than the amount of insulation set forth in Table No. 10-D, except for ducts and plenums used exclusively for evaporative cooling systems.

Approved materials shall be installed within ducts and plenums for insulating, sound deadening or other purposes. Materials shall have a mold-, humidity- and erosion-resistant face that meets the requirements of U.M.C. Standard No. 10-1. Duct liners in systems operating with air velocities exceeding 2,000 feet per minute shall be fastened with both adhesive and mechanical fasteners, and exposed edges shall have adequate treatment to withstand the operating velocity.

Insulation applied to the exterior surface of ducts located in buildings shall have a flame spread of not more than 25 and a smoke-density not exceeding 50 when tested as a composite installation, including insulation, facing materials, tapes and adhesives as normally applied.

> **EXCEPTION:** Insulation having a flame-spread index not exceeding 50 and a smoke-density not greater than 100 may be installed in dwellings or apartment houses where the duct system serves not more than one dwelling unit.

Faced insulations intended for installation on the exterior of ducts shall be legibly printed with the name of the manufacturer, nominal thickness of insulation and the flame-spread and smoke-developed ratings of the composite material.

Fire Dampers

Sec. 1006. (a) **Cross References.** See U.B.C. Standard No. 43-7 and Chapter 43 of the Building Code for the construction and installation of duct openings in walls and ceilings. U.B.C. Standard No. 43-7 is reprinted in Appendix A. Fire dampers shall not be located in a combustion-air duct or opening; see Uniform Mechanical Code Section 602 (b). Supply- and return-air ducts or plenums may pass through the wall, floor or ceiling separating a Group R, Division 3 from a Group M Occupancy without a fire damper, provided the ducts and plenums within the Group M Occupancy are constructed of steel having a thickness of not less than 0.019 inch (No. 26 galvanized sheet gage) and have no openings into the Group M Occupancy; see Building Code Section 503.

(b) **Access Openings.** Suitable openings with tightly fitted covers shall be provided to make fire dampers accessible for inspection and shall be large enough to permit maintenance and resetting of the damper. When a fire damper is installed in an air duct, a tight-fitting hinged or sliding access door shall be provided on the duct and the door shall comply with all of the following requirements:

1. The door shall be constructed of metal which is equal to or greater in thickness than the duct and of the same material.
2. Each access door shall have a label with letters not less than $^1/_2$ inch in height reading "FIRE DAMPER."
3. External duct insulation may conceal a fire damper access door when there is a label attached to the insulation indicating the exact location of the door.

(c) **Freedom from Interference.** Fire dampers shall be installed in a manner to ensure positive closing. Interior insulation and acoustical linings shall be placed so as not to interfere with positive closing of the fire damper.

(d) **Temperature Classification of Fusible Links.** Fusible links shall be classified in accordance with U.M.C. Standard No. 10-4. Fusible link-actuated fire dampers shall be equipped with listed fusible links having 165°F. temperature classification and listed to sustain the design load.

EXCEPTIONS: 1. Fire dampers serving duct openings in a warm-air furnace room or enclosure may be equipped with links having a high-temperature classification.

2. Fusible links with a temperature rating classification higher than ordinary may be used in locations approved by the building official.

(e) **Connection.** Ductwork shall be connected to fire damper sleeves or assemblies in such a way that collapse of the ductwork will not dislodge the damper.

Ventilating Ceilings

Sec. 1007. (a) **General.** Perforated ceilings may be used for air supply within the limitations of this section. Exit corridors when required to be of fire-resistive construction by Section 3305 (g) of the Building Code shall not have ventilating ceilings.

(b) **Requirements.** Ventilating ceilings shall comply with the following provisions:

1. Suspended ventilating ceiling material shall have a Class I flame-spread classification on both sides determined in accordance with Table No. 42-A of the Building Code. Suspended ventilating ceiling supports shall be of noncombustible materials.
2. Lighting fixtures recessed into the ventilating ceiling shall be of a type approved for that purpose.

Use of Under-floor Space as Supply Plenum

Sec. 1008. An under-floor space may be used as a supply plenum, provided:

1. The use of under-floor space shall be limited to dwelling units not more than two stories in height. Except for the floor immediately above the under-floor

plenum, supply ducts shall be provided extending from the plenum to registers on other floor levels.

2. Such spaces shall be cleaned of all loose combustible scrap material and shall be tightly and substantially enclosed.

3. The enclosing material of the under-floor space, including the sidewall insulation, shall be not more flammable than 1-inch (nominal) wood boards (flame-spread index of 200). Installation of foam plastics is regulated by the Building Code.

4. Access shall be through an opening in the floor and shall be not less than 24 inches by 24 inches.

5. A furnace supplying warm air to under-floor space shall be equipped with an automatic control which will start the air-circulating fan when the air in the furnace bonnet reaches a temperature not higher than 150°F. Such control shall be one that cannot be set higher than 150°F.

6. A furnace supplying warm air to such space shall be equipped with an approved temperature limit control that will limit outlet air temperature to 200°F.

7. A noncombustible receptacle shall be placed below each floor opening into the air chamber, and such receptacle shall conform to the following:

A. The receptacle shall be securely suspended from the floor members and shall be not more than 18 inches below the floor opening.

B. The area of the receptacle shall extend 3 inches beyond the opening on all sides.

C. The perimeter of the receptacle shall have a vertical lip at least 1 inch high at the open sides if it is at the level of the bottom of the joists, or 3 inches high if the receptacle is suspended.

8. Floor registers shall be designed for easy removal in order to give access for cleaning the receptacles.

9. Exterior walls and interior stud partitions shall be fire-stopped at the floor.

10. Each wall register shall be connected to the air chamber by a register box or boot.

11. A duct conforming with Section 1002 shall extend from the furnace supply outlet at least 6 inches below combustible framing.

12. The entire ground surface of the under-floor space shall be covered with a vapor barrier having a minimum thickness of 4 mils and a flamespread rating of 200 or less.

13. Fuel-gas lines and plumbing waste cleanouts are not located within the space.

Automatic Shutoffs

Sec. 1009. (a) **When Required.** Each single system providing heating or cooling air in excess of 2,000 cubic feet per minute in Group A, Divisions 1, 2 and 2.1; Group B, Division 2; Group E; Group I and Group R, Division 1 Occupancies shall be equipped with an automatic shutoff activated by smoke detectors. When the system serves more than one occupancy, automatic shutoff shall be provided.

EXCEPTIONS: 1. Automatic shutoffs need not be installed when all rooms have direct exit to the exterior of the building.

2. Automatic shutoffs need not be installed in systems specifically designed for smoke control.

(b) **Smoke Detection.** Smoke detectors required by Subsection (a) shall be installed in the main return-air duct ahead of any outside-air inlet or they may be installed in each room or space served by the return-air duct. Detectors shall also be installed in the supply duct, downstream of the filters. Activation of any detector shall cause the air-moving equipment to automatically shut down.

TABLE NO. 10-A—CONSTRUCTION DETAILS FOR RECTANGULAR SHEET METAL DUCTS FOR STATIC AIR PRESSURES UP TO 2 INCHES WC

For Pressures in Excess of 2-inch Water Column, Duct Wall Thickness Shall be Two Gages Heavier Than Set Forth in This Table.

Duct specifications shown here are applicable when ducts larger than 18 inches are cross broken. Where cross breaking is not used, duct wall thickness shall be two gages heavier on ducts 19 inches through 60 inches wide unless longitudinal standing seams are used.

MINIMUM METAL GAGES				
Steel—U.S. Standard Inches (Gage)	**Aluminum B. & S. Inches (Gage)**	**Copper Cold Rolled**	**Duct Dimension (In Inches)**	**PERMISSIBLE GIRTH JOINTS AND LONGITUDINAL SEAMS**
0.019 (26)	0.020 (24)	16 oz.	Up through 12	Drive Slip, Plain "S" Slip, or 1" Pocket Lock
0.024 (24)	0.025 (22)	24 oz.	13 through 18	Drive Slip, Plain "S" Slip, or 1" Pocket Lock
			19 through 30	Hemmed "S" Slip, 1" Bar Slip, or 1" Pocket Lock on 5′ centers Hemmed "S" Slip, 1" Bar Slip, or 1" Pocket Lock on 10′ Centers with 1" x 1" x ⅛" angles on center line between Hemmed "S" Slip, 1" Bar Slip, or 1" Pocket Lock on 10′ centers with Cross Break 1" Standing Seam on 5′ centers
0.030 (22)	0.032 (20)	32 oz.	31 through 42	1" Bar Slip, Reinforced Bar Slip, or Pocket Lock, on 5′ centers 1" Bar Slip, Reinforced Bar Slip, or Pocket Lock on 10′ centers with 1" x 1" x ⅛" angles on center line between 1" Standing Seam on 5′ centers Inside Longitudinal Standing Seams with 1" x 1" x ⅛" angles on 5′ center on exterior
			43 through 54	1½" Bar Slip, Reinforced Bar Slip, or Pocket Lock on 4′ centers 1½" Bar Slip, Reinforced Bar Slip, or Pocket Lock on 8′ centers with 1½" x 1½" x ⅛" angles on center line between 1½" Bar Slip, Reinforced Bar Slip, or Pocket Lock on 4′ centers with Cross Break
0.036 (20)	0.040 (18)	36 oz.	55 through 60	1½" Standing Seam on 3′ centers Inside Longitudinal Standing Seam with 1½" x 1½" x ⅛" angles on 4′ centers on exterior

0.036 (20)	0.040 (18)	36 oz.	61 through 84	Reinforced Bar Slip, Angle Slip, Alternate Bar Slip, or Angle Reinforced Pocket Lock on 4′ centers using 1½″ x 1½″ x ⅛″ reinforcing angles and with 1½″ x 1½″ x ⅛″ angles on center line between Reinforced Bar Slip, Angle Slip, Alternate Bar Slip, or Angle Reinforced Pocket Lock on 8′ centers using 1½″ x 1½″ x ⅛″ reinforcing angles and with 1½″ x 1½″ x ⅛″ angles 2′ on centers in between 1½″ Angle Reinforced Standing Seam on 2′ centers using 1½″ x 1½″ x ⅛″ reinforcing angles Inside Longitudinal Standing Seams with 1½″ x 1½″ x ⅛″ angles on 2′ centers on exterior
0.047 (18)	0.050 (16)	48 oz.	85 through 96	Companion Angles, Angle Slip, or Angle Reinforced Pocket Lock using 1½″ x 1½″ x 3/16″ companion or reinforcing angles on 4′ centers with 1½″ x 1½″ x 3/16″ angles on center line between Companion Angles, Angle Slip, or Angle Reinforced Pocket Lock using 1½″ x 1½″ x 3/16″ companion or reinforcing angles on 8′ centers with 1½″ x 1½″ x 3/16″ angles on 2′ centers in between 1½″ Angle Reinforced Standing Seam on 2′ centers using 1½″ x 1½″ x 3/16″ reinforcing angles Inside Longitudinal Standing Seams with 1½″ x 1½″ x 3/16″ angles on 2′ centers on exterior

(Continued)

TABLE NO. 10-A—CONSTRUCTION DETAILS FOR RECTANGULAR SHEET METAL DUCTS FOR STATIC AIR PRESSURES UP TO 2 INCHES WC—(Continued)

For Pressures in Excess of 2-inch Water Column, Duct Wall Thickness Shall be Two Gages Heavier Than Set Forth in This Table.

Duct specifications shown here are applicable when ducts larger than 18 inches are cross broken. Where cross breaking is not used, duct wall thickness shall be two gages heavier on ducts 19 inches through 60 inches wide unless longitudinal standing seams are used.

MINIMUM METAL GAGES				
Steel—U.S. Standard Inches (Gage)	**Aluminum B. & S. Inches (Gage)**	**Copper Cold Rolled**	**Duct Dimension (In Inches)**	**PERMISSIBLE GIRTH JOINTS AND LONGITUDINAL SEAMS**
0.047 (18)	0.050 (16)	48 oz.	Over 96	Companion Angles, Angle Slip, or Angle Reinforced Pocket Lock using 2″ x 2″ x ¼″ companion or reinforcing angles on 4′ centers with 2″ x 2″ x ¼″ angles on center line between Companion Angles, Angle Slip, or Angle Reinforced Pocket Lock using 2″ x 2″ x ¼″ companion or reinforcing angles on 8′ centers with 2″ x 2″ x ¼″ angles 2′ on center line between 1½″ Angle Reinforced Standing Seam on 2′ centers using 2″ x 2″ x ¼″ reinforcing angles Inside Longitudinal Standing Seams with 2″ x 2″ x ¼″ angles on 2′ centers on exterior

TABLE NO. 10-B—CONSTRUCTION DETAILS FOR ROUND AND FLAT-OVAL DUCTS

DUCT DIAMETER MAXIMUM WIDTH (In Inches)	Aluminum B. & S. Gage	STEEL—THICKNESS IN INCHES (STEEL—GALVANIZED SHEET GAGE)					GIRTH JOINTS[1]	
	Pressure ≤ 2″ WC	Pressure ≤ 2″ WC[2]		Pressure > 2″ ≤ 10″ WC			Pressure > 2″ ≤ 10″ WC	Minimum Girth Reinforcing, Maximum Spacing and Angle Size
	Round	Round	Flat-Oval	Spiral Seam	Longitudinal Seam	Welded Fittings		
Up to 9	24	0.019 (26)	0.024 (24)	0.019 (26)	0.024 (24)	0.030 (22)	2″ Slip	None
Over 9 Up to 14	24	0.019 (26)	0.024 (24)	0.024 (24)	0.030 (22)	0.036 (20)	4″ Slip	None
Over 14 Up to 23	22	0.024 (24)	0.030 (22)	0.024 (24)	0.030 (22)	0.036 (20)	4″ Slip	None
Over 23 Up to 37	20	0.030 (22)	0.036 (20)	0.030 (22)	0.036 (20)	0.036 (20)	4″ Slip	None
Over 37 Up to 51	18	0.036 (20)	0.047 (18)	0.036 (20)	0.036 (20)	0.047 (18)	$1\frac{1}{4}'' \times 1\frac{1}{4}'' \times \frac{1}{8}''$ Flange	$1\frac{1}{4}'' \times 1\frac{1}{4}'' \times \frac{1}{8}''$ on 72″
Over 51 Up to 61	16	0.047 (18)	0.058 (16)	X	0.047 (18)	0.047 (18)	$1\frac{1}{4}'' \times 1\frac{1}{4}'' \times \frac{1}{8}''$ Flange	$1\frac{1}{4}'' \times 1\frac{1}{4}'' \times \frac{1}{8}''$ on 72″
Over 61 Up to 84	14	0.058 (16)	0.070 (14)	X	0.058 (16)	0.058 (16)	$1\frac{1}{2}'' \times 1\frac{1}{2}'' \times \frac{1}{8}''$ Flange	$1\frac{1}{2}'' \times 1\frac{1}{2}'' \times \frac{1}{8}''$ on 48″

[1] For pressure ≤ 2 inches WC any of the following joints are acceptable: butt slip; pipe slip; pipe lock; roll slip; snap slip; plenum lock and companion flange.

[2] Acceptable longitudinal seams for pressure ≤ 2 inches WC: Acme (grooved); snap lock; standing and spiral.

TABLE NO. 10-C—THICKNESS OF METAL DUCTS AND PLENUMS USED FOR HEATING OR COOLING FOR A SINGLE DWELLING UNIT

	GALVANIZED STEEL		Approximate Aluminum B. & S. Gage
	Minimum Thickness (In Inches)	Equivalent Galvanized Sheet Gage No.	
Round ducts and enclosed rectangular ducts			
14″ or less	0.013	30	26
Over 14″	0.016	28	24
Exposed rectangular ducts			
14″ or less	0.016	28	24
Over 14″	0.019	26	22

TABLE NO. 10-D—INSULATION OF DUCTS

DUCT LOCATION	INSULATION TYPES MECHANICALLY COOLED	HEATING ZONE[1]	INSULATION TYPES HEATING ONLY
On roof on exterior of building	C, V[2] and W	I	A and W
		II	B and W
		III	C and W
Attics, garages and crawl spaces	A and V[2]	I	A
		II	A
		III	B
In walls,[3] within floor-ceiling spaces[3]	A and V[2]	I	A
		II	A
		III	B
Within the conditioned space or in basements; return ducts in air plenums	None required		None required
Cement slab or within ground	None required		None required

NOTE: Where ducts are used for both heating and cooling, the minimum insulation shall be as required for the most restrictive condition.

[1] Heating Degree Days:

Zone I	below 4500 D.D.
Zone II	4501 to 8000 D.D.
Zone III	over 8001 D.D.

[2] Vapor barriers shall be installed on supply ducts in spaces vented to the outside in geographic areas where the average July, August and September mean dew point temperature exceeds 60°F.

[3] Insulation may be omitted on that portion of a duct which is located within a wall- or a floor-ceiling space where:

a. Both sides of the space are exposed to conditioned air.
b. The space is not ventilated.
c. The space is not used as a return plenum.
d. The space is not exposed to unconditioned air.

Ceilings which form plenums need not be insulated.

INSULATION TYPES[4]:

A. A material with an installed conductance of 0.48 or the equivalent thermal resistance of 2.1.

Example of materials capable of meeting the above requirements:
1-inch, 0.60 lb./cu. ft. mineral fiber, rock, slag or glass blankets.
½-inch, 1.5 to 3 lb./cu. ft. mineral fiber blanket duct liner.
½-inch, 3 to 10 lb./cu. ft. mineral fiber board.

B. A material with an installed conductance of 0.24 or the equivalent thermal resistance of 4.2.

Examples of materials meeting the above requirements:
2-inch, 0.60 lb./cu. ft. mineral fiber blankets.
1-inch, 1.5 to 3 lb./cu. ft. mineral fiber blanket duct liner.
1-inch, 3 to 10 lb./cu. ft. mineral fiber board.

(Continued)

C. A material with an installed conductance 0.16 or the equivalent thermal resistance 6.3.

Examples of materials meeting the above requirements:
3-inch, 0.60 lb./cu. ft. mineral fiber blankets.
$1\frac{1}{2}$-inch, 1.5 to 3 lb./cu. ft. mineral fiber blanket duct liner.
$1\frac{1}{2}$-inch, 3 to 10 lb./cu. ft. mineral fiber board.

V. Vapor Barrier: Material with a perm rating not exceeding 0.5 perm. All joints to be sealed.

W. Approved weatherproof barrier.

[4] The example of materials listed under each type is not meant to limit other available thickness and density combinations with the equivalent installed conductance or resistance based on the insulation only.

TABLE NO. 10-E—DUCT SUPPORTS

Part I—VERTICAL DUCTS

MAXIMUM SIDE OF RECTANGULAR DUCT	METAL STRAP OR ANGLE BRACKET	MAXIMUM DIAMETER OF ROUND DUCTS	STRAPS
24"	1" x ⅛" (Strap)[1]	10"	0.047" (No. 18 gage) galvanized steel 2" wide[1]
36"	1" x 1" x ⅛" Angle[1]	20"	0.058" (No. 16 gage) galvanized steel 2" wide[1]
48"	1⅛" x 1⅛" x ⅛" Angle[1]	40"	⅛" steel x 1½"[1]
60"	1½" x 1½" x ⅛" Angle[1]	60"	⅛" steel x 2"[1]
Over 60"	2" x 2" x ⅛" Angle[1]	Over 60"	3⁄16" steel x 2"[1]

Part II—HORIZONTAL DUCTS

18"	1" x 18 Gage[2]	10"	Same gage as galvanized steel duct, 1" wide or (No. 18 gage galvanized steel wire) on 10' centers
30"	1" x 18 Gage[2]		
48"	1" x ⅛"[2]	20"	Same gage as galvanized steel duct, 1" wide or (No. 8 gage galvanized steel wire) tied to 1" galvanized steel band around duct on 10' centers
60"	1" x ⅛"[2]	40"	
80"	1" x ⅛"[2]		
		60"	Same gage as galvanized steel duct, 1½" wide on 6' centers
		Over 60"	Same gage as galvanized steel duct, 1½" wide on 4' centers

Part III—HORIZONTAL DUCTS—TRAPEZE-TYPE SUPPORTS

MAXIMUM DIAMETER OF ROUND DUCT OR SIDE OF RECTANGULAR DUCT	HORIZONTAL SUPPORT ANGLE[3]	HANGER
36"	1½" x 1½" x ⅛"	¼" round rod or 1" x 1" x ⅛" angle
48"	2" x 2" x ⅛"	¼" round rod or 1" x 1" x ⅛" angle
60"	2" x 2" x ⅛"	5⁄16" round rod or 1" x 1" x ⅛" angle
84"	2" x 2" x ⅛"	⅜" round rod or 1" x 1" x ⅛" angle

[1] Spaced vertically not more than 12 feet on centers.

[2] Spaced horizontally not more than 10 feet on centers.

[3] Spaced not more than 8 feet on centers.

TABLE NO. 10-F—ALTERNATE SUPPORTS FOR FACTORY-MADE AIR DUCTS

CLASS 1 DUCT MATERIAL	MIN. SUPPORT MATERIAL	MAX. SUPPORT SPACING, FT.
Rigid Round Fibrous	No. 26 gage × 5/8″ wide galvanized iron strap	6
Corrugated Metal	No. 18 gage galvanized iron wire	6
Flexible	No. 26 gage × 1 1/2″ wide galvanized iron strap	4

Chapter 11

VENTILATION SYSTEMS AND PRODUCT-CONVEYING SYSTEMS

Scope

Sec. 1101. This chapter applies to environmental air ventilation systems that are not a part of a heating or cooling system and to product-conveying duct systems. For commercial hood and kitchen ventilation systems, see Chapter 20.

Definitions

Sec. 1102. For the purposes of this chapter, the following definitions apply:

ENVIRONMENTAL AIR DUCT is ducting used for conveying air at temperatures not exceeding 250°F. to or from occupied areas of any occupancy through other than heating or air-conditioning systems, such as ventilation for human usage, domestic kitchen range exhaust, bathroom exhaust ducts, and domestic-type clothes dryer exhaust ducts.

FLAMMABLE VAPOR OR FUMES is the concentration of flammable constituents in air that exceeds 10 percent of its lower flammability limit (LFL).

PRODUCT-CONVEYING DUCT is ducting used for conveying solid particulates, such as refuse, dust, fumes and smoke; liquid particulate matter, such as spray residue, mists and fogs; vapors, such as vapors from flammable or corrosive liquids; noxious and toxic gases; and air at temperatures exceeding 250°F.

Motors, Fans and Filters

Sec. 1103. (a) **General.** Motors and fans shall be sized to provide the required air movement. Motors in areas which contain flammable vapors or dusts shall be of a type approved for such environments. A manually operated remote control installed at an approved location shall be provided to shut off fans or blowers in flammable vapor or dust systems. Electrical equipment used in operations that generate explosive or flammable vapors, fumes or dusts shall be interlocked with the ventilation system so that the equipment cannot be operated unless the ventilation fans are in operation. Motors for fans used to convey flammable vapors or dusts shall be located outside the duct or shall be protected with approved shields and dustproofing. Motors and fans shall be accessible for servicing and maintenance.

(b) **Fans.** Parts of fans in contact with explosive or flammable vapors, fumes or dusts shall be of nonferrous or nonsparking materials or their casing shall be lined or constructed of such material. When the size and hardness of materials passing through a fan could produce a spark, both the fan and the casing shall be of nonsparking materials. When fans are required to be spark resistant, their bearings shall not be within the airstream, and all parts of the fan shall be grounded. Fans in systems handling materials that are likely to clog the blades, and fans in buffing or woodworking exhaust systems, shall be of the radial-blade or tube-axial-type.

Equipment used to exhaust explosive or flammable vapors, fumes or dusts shall bear an identification plate stating the ventilation rate for which the system was designed.

Fans located in systems conveying corrosives shall be of materials that are resistant to the corrosive or shall be coated with corrosion-resistant materials.

(c) **Air Filters.** Air filters shall be listed units. Liquid adhesive coatings used on filters shall have a flash point of 350°F. or higher, as determined by U.F.C. Standard No. 9-6.

Environmental Air Ducts

Sec. 1104. Environmental air ducts not regulated by other provisions of this code shall comply with this section. Ducts shall be substantially airtight and shall comply with the provisions of Chapter 10. Exhaust ducts shall terminate outside the building and shall be equipped with back-draft dampers. Environmental air ducts which have an alternate function as a part of an approved smoke-control system do not require design as Class 1 product-conveying ducts.

Ducts used for domestic kitchen range ventilation and domestic clothes dryers shall be of metal and shall have smooth interior surfaces. Commercial dryer exhaust ducts shall be installed in accordance with their listing. For additional requirements for domestic dryer exhaust systems, see Section 1903.

> **EXCEPTION:** Approved flexible duct connectors not more than 6 feet in length may be used in connection with domestic dryer exhausts. Flexible duct connectors shall not be concealed within construction.

Bathroom and laundry room exhaust ducts may be of gypsum wallboard subject to the limitations of Section 1002 (a). Exhaust ducts shall not extend into or through ducts or plenums.

Design of Product-conveying Ventilation Systems

Sec. 1105. (a) **General.** A mechanical ventilation or exhaust system shall be installed to control, capture and remove emissions generated from product use or handling when required by the Building Code or Fire Code and when such emissions result in a hazard to life or property. The design of the system shall be such that the emissions are confined to the area in which they are generated by air currents, hoods or enclosures and shall be exhausted by a duct system to a safe location or treated by removing contaminants. Ducts conveying explosives or flammable vapors, fumes or dusts shall extend directly to the exterior of the building without entering other spaces. Exhaust ducts shall not extend into or through ducts and plenums.

> **EXCEPTION:** Ducts conveying vapor or fumes having flammable constituents less than 25 percent of their lower flammability limit (LFL) may pass through other spaces.

Separate and distinct systems shall be provided for incompatible materials.

Contaminated air shall not be recirculated to occupied areas unless contaminants have been removed. Air contaminated with explosive or flammable vapors, fumes or dusts; flammable or toxic gases, or radioactive material shall not be recirculated.

(b) **Minimum Velocities and Circulation.** The velocity and circulation of air in work areas shall be such that contaminants are captured by an airstream at the area where the emissions are generated and conveyed into a product-conveying duct system. Mixtures within work areas where contaminants are generated shall be diluted below 25 percent of their lower explosive limit or lower flammability limit with air which does not contain other contaminants. The velocity of air within the duct shall be not less than set forth in Table No. 11-A.

Systems for removal of vapors, gases and smoke shall be designed by the constant velocity or equal friction methods. Systems conveying particulate matter shall be designed employing the constant velocity method. Systems conveying explosive or radioactive materials shall be prebalanced through duct sizing. Other systems may be designed with balancing devices such as dampers. Dampers provided to balance air flow shall be provided with securely fixed minimum-position blocking devices to prevent restricting flow below the required volume or velocity.

(c) **Makeup Air.** Makeup air shall be provided to replenish air exhausted by the ventilation system. Makeup-air intakes shall be located so as to avoid recirculation of contaminated air within enclosures.

Hoods and Enclosures

Sec. 1106. Hoods and enclosures shall be used when contaminants originate in a concentrated area. The design of the hood or enclosure shall be such that air currents created by the exhaust systems will capture the contaminants and transport them directly to the exhaust duct. The volume of air shall be sufficient to dilute explosive or flammable vapors, fumes or dusts as set forth in Section 1105 (b). Hoods of steel shall have a base metal thickness not less than .027 inch (22 gage) for Class 1 and Class 5 metal duct systems; .033 inch (20 gage) for hoods serving a Class 2 duct system; .044 inch (18 gage) for hoods serving a Class 3 duct system; and .068 inch (14 gage) for hoods serving a Class 4 duct system. Approved nonmetallic hoods and duct systems may be used for Class 5 corrosive systems when the corrosive mixture is nonflammable. Metal hoods used with Class 5 duct systems shall be protected with suitable corrosion-resistant material. Edges of hoods shall be rounded. The minimum clearance between hoods and combustible construction shall be the clearance required by the duct system.

Product-conveying Ducts

Sec. 1107. (a) **Classification.** Product-conveying ducts shall be classified according to their use, as follows:

Class 1. Ducts conveying nonabrasives, such as smoke, spray, mists, fogs, noncorrosive fumes and gases, light fine dusts or powders.

Class 2. Ducts conveying moderately abrasive particulate in light concentrations, such as sawdust and grain dust, buffing and polishing dust.

Class 3. Ducts conveying Class 2 materials in high concentrations and highly abrasive materials in low concentrations, such as manganese, steel chips and coke.

Class 4. Ducts conveying highly abrasive material in high concentrations.

Class 5. Ducts conveying corrosives, such as acid vapors.

(b) **Materials.** Materials used in product-conveying duct systems shall be suitable for the intended use and shall be of metal.

> **EXCEPTIONS:** 1. Asbestos-cement, concrete, clay or ceramic materials may be used when it is shown that these materials will be equivalent to metal ducts installed in accordance with this chapter.
>
> 2. Ducts serving a Class 5 system may be constructed of approved nonmetallic material when the corrosive characteristics of the material being conveyed make a metal system unsuitable and when the mixture being conveyed is nonflammable.
>
> Approved nonmetallic material shall be either a listed product having a flame-spread index of 25 or less and a smoke-developed rating of 50 or less on both inside and outside surfaces without evidence of continued progressive combustion, or shall have a flame-spread index of 25 or less and shall be installed with an automatic fire-sprinkler protection system inside the duct.
>
> 3. Ducts used in central vacuum-cleaning systems within a dwelling unit may be of Schedule 40 PVC pipe. Penetrations of fire walls, floor-ceiling or roof-ceiling assemblies shall comply with Sections 4304 and 4305 of the Building Code. Copper or ferrous pipes or conduits extending from within the separation between a garage and dwelling unit to the central vacuuming unit may be used.

Aluminum ducts shall not be used in systems conveying flammable vapors, fumes or explosive dusts nor in Class 2, 3 or 4 systems. Galvanized steel and aluminum ducts shall not be used when the temperature of the material being conveyed exceeds 400°F.

Metal ducts used in Class 5 systems that are not resistant to the corrosiveness of the product shall be protected with appropriate corrosion-resistant material.

(c) **Construction.** Ducts used for conveying products shall be of substantial airtight construction and shall not have openings other than those required for operation and maintenance of the system. Ducts constructed of steel shall comply with Table No. 11-B or Table No. 11-C.

> **EXCEPTIONS:** 1. Class 1 product-conveying ducts that operate at less than 4 inches water column negative pressure and convey noncorrosive, nonflammable and nonexplosive materials at temperatures not exceeding 250°F. may be constructed in accordance with the Tables Nos. 10-A, 10-B, 10-E or, with prior approval, U.M.C. Standard No. 10-2.
>
> 2. Ducts used in central vacuuming systems within a dwelling unit may be constructed of Schedule 40 PVC pipe. Penetrations of fire-resistive walls, floor-ceiling or roof-ceilings assemblies shall comply with Sections 4304 and 4305 of the Building Code. Copper or ferrous pipes or conduit extending from within the separation between a garage and dwelling unit to the central vacuum unit may be used.

The use of rectangular ducts conveying particulates shall be subject to approval of the building official. The design of rectangular ducts shall consider the adhesiveness and buildup of products being conveyed within the duct.

Aluminum construction may be used in Class 1 duct systems only. The thickness of aluminum ducts shall be at least two Brown and Sharpe gages thicker than the gages required for steel ducts set forth in Tables Nos. 11-B and 11-C.

(d) **Fittings.** Fittings in Class 2, 3 and 4 systems shall be not less than two gages thicker than the thickness required for straight runs. Flexible metallic duct may be used for connecting ductwork to vibrating equipment. Duct systems subject to wide temperature fluctuations shall be provided with expansion joints.

Branches shall connect to main ducts at the large end of transitions at an angle not exceeding 45 degrees.

Except for ducts used to convey noncorrosive vapors with no particulate, accessible cleanouts shall be provided at 10-foot intervals and at changes in direction. Access openings shall also be provided for access to sprinklers and other equipment within the duct which requires servicing.

(e) **Explosion Venting.** Ducts conveying explosive dusts shall have explosion vents, openings protected by antiflashback swing valves or rupture diaphragms. Openings to relieve explosive forces shall be located outside the building. When relief devices cannot provide sufficient pressure relief, ductwork shall be designed to withstand an internal pressure of not less than 100 pounds per square inch.

(f) **Supports.** Spacing of supports for ducts shall not exceed 12 feet for 8-inch ducts nor 20 feet for larger ducts unless justified by the design. The design of supports shall assume that 50 percent of the duct is full of the particulate being conveyed.

(g) **Fire Protection.** Sprinklers or other fire-protection devices shall be installed within ducts having a cross-sectional dimension exceeding 10 inches when the duct conveys flammable vapors or fumes. Sprinklers shall be installed at 12-foot intervals in horizontal ducts and at changes in direction. In vertical runs, sprinklers shall be installed at the top and at alternate floor levels.

(h) **Clearances.** Ducts conveying flammable or explosive vapors, fumes or dusts shall have a clearance from combustibles of not less than 18 inches. This clearance may be reduced when the combustible construction is protected in accordance with Table No. 5-B.

Ducts conveying products at temperatures exceeding 125°F. shall have a clearance to combustible materials not less than the following: 125°F. to 250°F—1 inch; 251°F. to 600°F—8 inches. For temperatures exceeding 600°F., the clearance shall be not less than required for chimneys in Table No. 9-C.

(i) **Protection from Physical Damage.** Ducts installed in locations where they are subject to physical damage shall be protected by suitable guards.

(j) **Exhaust Outlets.** Outlets for exhausts that exceed 600°F. shall be in accordance with Table No. 9-C.

The termination point for exhaust ducts discharging to the atmosphere shall be not less than the following:

1. Ducts conveying explosive or flammable vapors, fumes or dusts: 30 feet from property line; 10 feet from openings into the building; 6 feet from exterior walls or roofs; 30 feet from combustible walls or openings into the building which are in the direction of the exhaust discharge; 10 feet above adjoining grade.
2. Other product-conveying outlets: 10 feet from property line; 3 feet from exterior wall or roof; 10 feet from openings into the building; 10 feet above adjoining grade.
3. Environmental air duct exhaust: 3 feet from property line; 3 feet from openings into the building.

TABLE NO. 11-A—MINIMUM CONVEYING VELOCITIES—FPM

	FEET PER MINUTE
Vapors, gases, smoke, fumes	Any
Fine light dusts, such as cotton, lint and wood flour (100 mesh and under)	2000
Dry dusts; powders, such as fine rubber molding powder, soap dust	2500[1]
Industrial dusts	
Average dusts, such as sawdust, grinding dust, coal dust	3500
Heavy dusts, such as metal turnings, lead dusts	4000
Moist dusts and chips, such as lead dust with chips, sticky buffing lint, quick-lime dust	4500

[1] The velocity for aluminum and magnesium powder shall be not less than 4000 feet per minute.

TABLE NO. 11-B—MINIMUM SHEET METAL THICKNESS FOR ROUND DUCTS

NEGATIVE PRESSURE	REINF. SPACING (Inches)	CLASS 1								
		Up to 7″	8″ to 11″	12″ to 15″	16″ to 19″	20″ to 23″	24″ to 35″	36″ to 47″	48″ to 59″	60″
To 7″	0	.021 (24 ga.)	.021 (24 ga.)	.033 (20 ga.)	.044 (18 ga.)	.055 (16 ga.)	.068 (14 ga.)	.127 (10 ga.)		
	96	.021 (24 ga.)	.021 (24 ga.)	.021 (24 ga.)	.027 (22 ga.)	.033 (20 ga.)	.044 (18 ga.)	.055 (16 ga.)	.068 (14 ga.)	.068 (14 ga.)
	48	.021 (24 ga.)	.021 (24 ga.)	.021 (24 ga.)	.021 (24 ga.)	.021 (24 ga.)	.027 (22 ga.)	.033 (20 ga.)	.044 (18 ga.)	.055 (16 ga.)
	24	.021 (24 ga.)	.021 (24 ga.)	.021 (24 ga.)	.021 (24 ga.)	.021 (24 ga.)	.021 (24 ga.)	.027 (22 ga.)	.033 (20 ga.)	.044 (18 ga.)
8″ to 11″	0	.021 (24 ga.)	.027 (22 ga.)	.044 (18 ga.)	.055 (16 ga.)	.068 (14 ga.)	.097 (12 ga.)			
	96	.021 (24 ga.)	.027 (22 ga.)	.027 (22 ga.)	.044 (18 ga.)	.044 (18 ga.)	.044 (18 ga.)	.068 (14 ga.)	.097 (12 ga.)	.097 (12 ga.)
	48	.021 (24 ga.)	.021 (24 ga.)	.021 (24 ga.)	.027 (22 ga.)	.033 (20 ga.)	.033 (20 ga.)	.055 (16 ga.)	.068 (14 ga.)	.068 (14 ga.)
	24	.021 (24 ga.)	.021 (24 ga.)	.021 (24 ga.)	.021 (24 ga.)	.027 (22 ga.)	.027 (22 ga.)	.044 (18 ga.)	.055 (16 ga.)	.055 (16 ga.)
12″ to 15″	0	.021 (24 ga.)	.033 (20 ga.)	.055 (16 ga.)	.068 (14 ga.)	.097 (12 ga.)	.097 (12 ga.)			
	96	.021 (24 ga.)	.027 (22 ga.)	.044 (18 ga.)	.044 (18 ga.)	.055 (16 ga.)	.055 (16 ga.)	.097 (12 ga.)	.112 (11 ga.)	.112 (11 ga.)
	48	.021 (24 ga.)	.027 (22 ga.)	.027 (22 ga.)	.033 (20 ga.)	.044 (18 ga.)	.044 (18 ga.)	.068 (14 ga.)	.068 (14 ga.)	.097 (12 ga.)
	24	.021 (24 ga.)	.021 (24 ga.)	.021 (24 ga.)	.027 (22 ga.)	.027 (22 ga.)	.027 (22 ga.)	.055 (16 ga.)	.055 (16 ga.)	.055 (16 ga.)
16″ to 20″	0	.021 (24 ga.)	.044 (18 ga.)	.068 (14 ga.)	.097 (12 ga.)	.112 (11 ga.)				
	96	.021 (24 ga.)	.033 (20 ga.)	.055 (16 ga.)	.055 (16 ga.)	.068 (14 ga.)	.068 (14 ga.)	.112 (11 ga.)	.112 (11 ga.)	.112 (11 ga.)
	48	.021 (24 ga.)	.027 (22 ga.)	.033 (20 ga.)	.044 (18 ga.)	.055 (16 ga.)	.055 (16 ga.)	.068 (14 ga.)	.097 (12 ga.)	.112 (11 ga.)
	24	.021 (24 ga.)	.021 (24 ga.)	.027 (22 ga.)	.033 (20 ga.)	.044 (18 ga.)	.044 (18 ga.)	.055 (16 ga.)	.068 (14 ga.)	.097 (12 ga.)
		CLASS 2								
To 7″	0	.027 (22 ga.)	.027 (22 ga.)	.033 (20 ga.)	.044 (18 ga.)	.055 (16 ga.)	.068 (14 ga.)	.127 (10 ga.)		
	96	.027 (22 ga.)	.027 (22 ga.)	.033 (20 ga.)	.033 (20 ga.)	.044 (18 ga.)	.044 (18 ga.)	.055 (16 ga.)	.068 (14 ga.)	.068 (14 ga.)
	48	.027 (22 ga.)	.027 (22 ga.)	.033 (20 ga.)	.033 (20 ga.)	.044 (18 ga.)	.044 (18 ga.)	.055 (16 ga.)	.055 (16 ga.)	.055 (16 ga.)
	24	.027 (22 ga.)	.027 (22 ga.)	.033 (20 ga.)	.033 (20 ga.)	.044 (18 ga.)	.044 (18 ga.)	.055 (16 ga.)	.055 (16 ga.)	.055 (16 ga.)
8″ to 11″	0	.027 (22 ga.)	.027 (22 ga.)	.044 (18 ga.)	.055 (16 ga.)	.068 (14 ga.)	.097 (12 ga.)			
	96	.027 (22 ga.)	.027 (22 ga.)	.033 (20 ga.)	.044 (18 ga.)	.044 (18 ga.)	.044 (18 ga.)	.068 (14 ga.)	.097 (12 ga.)	.097 (12 ga.)
	48	.027 (22 ga.)	.027 (22 ga.)	.033 (20 ga.)	.033 (20 ga.)	.044 (18 ga.)	.044 (18 ga.)	.055 (16 ga.)	.068 (14 ga.)	.068 (14 ga.)
	24	.027 (22 ga.)	.027 (22 ga.)	.033 (20 ga.)	.033 (20 ga.)	.044 (18 ga.)	.044 (18 ga.)	.055 (16 ga.)	.055 (16 ga.)	.055 (16 ga.)

(Continued)

TABLE NO. 11-B—MINIMUM SHEET METAL THICKNESS FOR ROUND DUCTS—(Continued)

12″ to 15″	0	.027 (22 ga.)	.033 (20 ga.)	.055 (16 ga.)	.068 (14 ga.)	.097 (12 ga.)	.097 (12 ga.)			
	96	.027 (22 ga.)	.033 (20 ga.)	.044 (18 ga.)	.044 (18 ga.)	.055 (16 ga.)	.055 (16 ga.)	.097 (12 ga.)	.112 (11 ga.)	.112 (11 ga.)
	48	.027 (22 ga.)	.027 (22 ga.)	.033 (20 ga.)	.033 (20 ga.)	.044 (18 ga.)	.044 (18 ga.)	.068 (14 ga.)	.068 (14 ga.)	.097 (12 ga.)
	24	.027 (22 ga.)	.027 (22 ga.)	.033 (20 ga.)	.033 (20 ga.)	.044 (18 ga.)	.044 (18 ga.)	.055 (16 ga.)	.055 (16 ga.)	.055 (16 ga.)
16″ to 20″	0	.027 (22 ga.)	.044 (18 ga.)	.068 (14 ga.)	.097 (12 ga.)	.112 (11 ga.)				
	96	.027 (22 ga.)	.033 (20 ga.)	.055 (16 ga.)	.055 (16 ga.)	.068 (14 ga.)	.068 (14 ga.)	.112 (11 ga.)	.112 (11 ga.)	.112 (11 ga.)
	48	.027 (22 ga.)	.033 (20 ga.)	.033 (20 ga.)	.044 (18 ga.)	.055 (16 ga.)	.055 (16 ga.)	.068 (14 ga.)	.068 (14 ga.)	.097 (12 ga.)
	24	.027 (22 ga.)	.033 (20 ga.)	.033 (20 ga.)	.033 (20 ga.)	.044 (18 ga.)	.044 (18 ga.)	.055 (16 ga.)	.055 (16 ga.)	.055 (16 ga.)
		CLASS 3								
To 7″	0	.033 (20 ga.)	.033 (20 ga.)	.044 (18 ga.)	.044 (18 ga.)	.055 (16 ga.)	.068 (14 ga.)	.127 (10 ga.)		
	96	.033 (20 ga.)	.033 (20 ga.)	.044 (18 ga.)	.044 (18 ga.)	.055 (16 ga.)	.055 (16 ga.)	.068 (14 ga.)	.068 (14 ga.)	.068 (14 ga.)
	48	.033 (20 ga.)	.033 (20 ga.)	.044 (18 ga.)	.044 (18 ga.)	.055 (16 ga.)	.055 (16 ga.)	.068 (14 ga.)	.068 (14 ga.)	.068 (14 ga.)
	24	.033 (20 ga.)	.033 (20 ga.)	.044 (18,ga.)	.044 (18 ga.)	.055 (16 ga.)	.055 (16 ga.)	.068 (14 ga.)	.068 (14 ga.)	.068 (14 ga.)
8″ to 11″	0	.033 (20 ga.)	.033 (20 ga.)	.044 (18 ga.)	.055 (16 ga.)	.068 (14 ga.)	.097 (12 ga.)			
	96	.033 (20 ga.)	.033 (20 ga.)	.044 (18 ga.)	.044 (18 ga.)	.055 (16 ga.)	.055 (16 ga.)	.068 (14 ga.)	.097 (12 ga.)	.097 (12 ga.)
	48	.033 (20 ga.)	.033 (20 ga.)	.044 (18 ga.)	.044 (18 ga.)	.055 (16 ga.)	.055 (16 ga.)	.068 (14 ga.)	.068 (14 ga.)	.068 (14 ga.)
	24	.033 (20 ga.)	.033 (20 ga.)	.044 (18 ga.)	.044 (18 ga.)	.055 (16 ga.)	.055 (16 ga.)	.068 (14 ga.)	.068 (14 ga.)	.068 (14 ga.)
12″ to 15″	0	.033 (20 ga.)	.033 (20 ga.)	.055 (16 ga.)	.068 (14 ga.)	.097 (12 ga.)	.097 (12 ga.)			
	96	.033 (20 ga.)	.033 (20 ga.)	.044 (18 ga.)	.044 (18 ga.)	.055 (16 ga.)	.055 (16 ga.)	.097 (12 ga.)	.112 (11 ga.)	.112 (11 ga.)
	48	.033 (20 ga.)	.033 (20 ga.)	.044 (18 ga.)	.044 (18 ga.)	.055 (16 ga.)	.055 (16 ga.)	.068 (14 ga.)	.068 (14 ga.)	.068 (14 ga.)
	24	.033 (20 ga.)	.033 (20 ga.)	.044 (18 ga.)	.044 (18 ga.)	.055 (16 ga.)	.055 (16 ga.)	.068 (14 ga.)	.068 (14 ga.)	.068 (14 ga.)
16″ to 20″	0	.033 (20 ga.)	.044 (18 ga.)	.068 (14 ga.)	.097 (12 ga.)	.112 (11 ga.)				
	96	.033 (20 ga.)	.033 (20 ga.)	.055 (16 ga.)	.055 (16 ga.)	.068 (14 ga.)	.068 (14 ga.)	.112 (11 ga.)	.112 (11 ga.)	.112 (11 ga.)
	48	.033 (20 ga.)	.033 (20 ga.)	.044 (18 ga.)	.044 (18 ga.)	.055 (16 ga.)	.055 (16 ga.)	.068 (14 ga.)	.068 (14 ga.)	.097 (12 ga.)
	24	.033 (20 ga.)	.033 (20 ga.)	.044 (18 ga.)	.044 (18 ga.)	.055 (16 ga.)	.055 (16 ga.)	.068 (14 ga.)	.068 (14 ga.)	.068 (14 ga.)

NEGATIVE PRESSURE	REINF. SPACING (Inches)	CLASS 4								
		Up to 7″	8″ to 11″	12″ to 15″	16″ to 19″	20″ to 23″	24″ to 35″	36″ to 47″	48″ to 59″	60″
To 7″	0	.055 (16 ga.)	.055 (16 ga.)	.055 (16 ga.)	.055 (16 ga.)	.068 (14 ga.)	.068 (14 ga.)	.127 (10 ga.)		
	96	.055 (16 ga.)	.055 (16 ga.)	.055 (16 ga.)	.055 (16 ga.)	.068 (14 ga.)	.068 (14 ga.)	.097 (12 ga.)	.097 (12 ga.)	.097 (12 ga.)
	48	.055 (16 ga.)	.055 (16 ga.)	.055 (16 ga.)	.055 (16 ga.)	.068 (14 ga.)	.068 (14 ga.)	.097 (12 ga.)	.097 (12 ga.)	.097 (12 ga.)
	24	.055 (16 ga.)	.055 (16 ga.)	.055 (16 ga.)	.055 (16 ga.)	.068 (14 ga.)	.068 (14 ga.)	.097 (12 ga.)	.097 (12 ga.)	.097 (12 ga.)
8″ to 11″	0	.055 (16 ga.)	.055 (16 ga.)	.055 (16 ga.)	.055 (16 ga.)	.068 (14 ga.)	.097 (12 ga.)			
	96	.055 (16 ga.)	.055 (16 ga.)	.055 (16 ga.)	.055 (16 ga.)	.068 (14 ga.)	.068 (14 ga.)	.097 (12 ga.)	.097 (12 ga.)	.097 (12 ga.)
	48	.055 (16 ga.)	.055 (16 ga.)	.055 (16 ga.)	.055 (16 ga.)	.068 (14 ga.)	.068 (14 ga.)	.097 (12 ga.)	.097 (12 ga.)	.097 (12 ga.)
	24	.055 (16 ga.)	.055 (16 ga.)	.055 (16 ga.)	.055 (16 ga.)	.068 (14 ga.)	.068 (14 ga.)	.097 (12 ga.)	.097 (12 ga.)	.097 (12 ga.)
12″ to 15″	0	.055 (16 ga.)	.055 (16 ga.)	.055 (16 ga.)	.068 (14 ga.)	.097 (12 ga.)	.097 (12 ga.)			
	96	.055 (16 ga.)	.055 (16 ga.)	.055 (16 ga.)	.055 (16 ga.)	.068 (14 ga.)	.068 (14 ga.)	.097 (12 ga.)	.112 (11 ga.)	.112 (11 ga.)
	48	.055 (16 ga.)	.055 (16 ga.)	.055 (16 ga.)	.055 (16 ga.)	.068 (14 ga.)	.068 (14 ga.)	.097 (12 ga.)	.097 (12 ga.)	.097 (12 ga.)
	24	.055 (16 ga.)	.055 (16 ga.)	.055 (16 ga.)	.055 (16 ga.)	.068 (14 ga.)	.068 (14 ga.)	.097 (12 ga.)	.097 (12 ga.)	.097 (12 ga.)
16″ to 20″	0	.055 (16 ga.)	.055 (16 ga.)	.068 (14 ga.)	.097 (12 ga.)	.112 (11 ga.)				
	96	.055 (16 ga.)	.055 (16 ga.)	.055 (16 ga.)	.055 (16 ga.)	.068 (14 ga.)	.068 (14 ga.)	.112 (11 ga.)	.112 (11 ga.)	.112 (11 ga.)
	48	.055 (16 ga.)	.055 (16 ga.)	.055 (16 ga.)	.055 (16 ga.)	.068 (14 ga.)	.068 (14 ga.)	.097 (12 ga.)	.097 (12 ga.)	.097 (12 ga.)
	24	.055 (16 ga.)	.055 (16 ga.)	.055 (16 ga.)	.055 (16 ga.)	.068 (14 ga.)	.068 (14 ga.)	.097 (12 ga.)	.097 (12 ga.)	.097 (12 ga.)

TABLE NO. 11-C—MINIMUM SHEET METAL THICKNESS FOR RECTANGULAR DUCTS

NEGATIVE PRESSURE	REINFORCEMENT SPACING	LONGEST SIDE OF DUCT									
		CLASS 1					CLASS 2				
		Up to 12″	23″ to 24″	25″ to 36″	37″ to 48″	49″ to 60″	Up to 12″	13″ to 24″	25″ to 36″	37″ to 48″	49″ to 60″
To 7″	48	.021 (24 ga.)	.033 (20 ga.)	.055 (16 ga.)	.068 (14 ga.)		.033 (20 ga.)	.044 (18 ga.)	.055 (16 ga.)	.068 (14 ga.)	
To 7″	24	.021 (24 ga.)	.027 (22 ga.)	.033 (20 ga.)	.033 (20 ga.)	.033 (20 ga.)	.033 (20 ga.)	.044 (18 ga.)	.055 (16 ga.)	.055 (16 ga.)	.055 (16 ga.)
To 7″	12	.021 (24 ga.)	.021 (24 ga.)	.021 (24 ga.)	.021 (24 ga.)	.021 (24 ga.)	.033 (20 ga.)	.044 (18 ga.)	.055 (16 ga.)	.055 (16 ga.)	.055 (16 ga.)
8″ to 11″	48	.027 (22 ga.)	.068 (14 ga.)	.097 (12 ga.)	.098 (12 ga.)		.033 (20 ga.)	.068 (14 ga.)	.097 (12 ga.)	.097 (12 ga.)	
8″ to 11″	24	.027 (22 ga.)	.055 (16 ga.)	.055 (16 ga.)	.068 (14 ga.)	.068 (14 ga.)	.033 (20 ga.)	.055 (16 ga.)	.055 (16 ga.)	.068 (14 ga.)	.068 (14 ga.)
8″ to 11″	12	.021 (24 ga.)	.027 (22 ga.)	.027 (22 ga.)	.027 (22 ga.)	.027 (22 ga.)	.033 (20 ga.)	.044 (18 ga.)	.055 (16 ga.)	.055 (16 ga.)	.055 (16 ga.)
12″ to 15″	48	.044 (18 ga.)	.097 (12 ga.)				.044 (18 ga.)	.044 (18 ga.)			
12″ to 15″	24	.044 (18 ga.)	.055 (16 ga.)	.097 (12 ga.)	.097 (12 ga.)	.097 (12 ga.)	.044 (18 ga.)	.044 (18 ga.)	.097 (12 ga.)	.097 (12 ga.)	.097 (12 ga.)
12″ to 15″	12	.027 (22 ga.)	.044 (18 ga.)	.044 (18 ga.)	.044 (18 ga.)	.044 (18 ga.)	.033 (20 ga.)	.044 (18 ga.)	.055 (16 ga.)	.055 (16 ga.)	.055 (16 ga.)
16″ to 20″	48	.068 (14 ga.)	.112 (11 ga.)				.068 (14 ga.)	.112 (11 ga.)			
16″ to 20″	24	.068 (14 ga.)	.068 (14 ga.)	.112 (11 ga.)	.112 (11 ga.)	.112 (11 ga.)	.068 (14 ga.)	.068 (14 ga.)	.112 (11 ga.)	.112 (11 ga.)	.112 (11 ga.)
16″ to 20″	12	.033 (20 ga.)	.068 (14 ga.)	.068 (14 ga.)	.068 (14 ga.)	.068 (14 ga.)	.033 (20 ga.)	.044 (18 ga.)	.068 (14 ga.)	.068 (14 ga.)	.068 (14 ga.)
		CLASS 3					CLASS 4				
To 7″	48	.044 (18 ga.)	.055 (16 ga.)	.068 (14 ga.)	.068 (14 ga.)		.055 (16 ga.)	.068 (14 ga.)	.097 (12 ga.)	.097 (12 ga.)	
To 7″	24	.044 (18 ga.)	.055 (16 ga.)	.068 (14 ga.)	.068 (14 ga.)	.068 (14 ga.)	.055 (16 ga.)	.068 (14 ga.)	.097 (12 ga.)	.097 (12 ga.)	.097 (12 ga.)
To 7″	12	.044 (18 ga.)	.055 (16 ga.)	.068 (14 ga.)	.068 (14 ga.)	.068 (14 ga.)	.055 (16 ga.)	.068 (14 ga.)	.097 (12 ga.)	.097 (12 ga.)	.097 (12 ga.)
8″ to 11″	48	.044 (18 ga.)	.068 (14 ga.)	.097 (12 ga.)	.097 (12 ga.)		.055 (16 ga.)	.068 (14 ga.)	.097 (12 ga.)	.097 (12 ga.)	
8″ to 11″	24	.044 (18 ga.)	.055 (16 ga.)	.068 (14 ga.)	.068 (14 ga.)	.068 (14 ga.)	.055 (16 ga.)	.068 (14 ga.)	.097 (12 ga.)	.097 (12 ga.)	.097 (12 ga.)
8″ to 11″	12	.044 (18 ga.)	.055 (16 ga.)	.068 (14 ga.)	.068 (14 ga.)	.068 (14 ga.)	.055 (16 ga.)	.068 (14 ga.)	.097 (12 ga.)	.097 (12 ga.)	.097 (12 ga.)
12″ to 15″	48	.044 (18 ga.)	.097 (12 ga.)				.055 (16 ga.)	.097 (12 ga.)			
12″ to 15″	24	.044 (18 ga.)	.055 (16 ga.)	.097 (12 ga.)	.097 (12 ga.)	.097 (12 ga.)	.055 (16 ga.)	.068 (14 ga.)	.097 (12 ga.)	.097 (12 ga.)	.097 (12 ga.)
12″ to 15″	12	.044 (18 ga.)	.055 (16 ga.)	.068 (14 ga.)	.068 (14 ga.)	.068 (14 ga.)	.055 (16 ga.)	.068 (14 ga.)	.097 (12 ga.)	.097 (12 ga.)	.098 (12 ga.)
16″ to 20″	48	.068 (14 ga.)	.112 (11 ga.)				.055 (16 ga.)	.112 (11 ga.)			
16″ to 20″	24	.068 (14 ga.)	.068 (14 ga.)	.112 (11 ga.)	.112 (11 ga.)	.112 (11 ga.)	.055 (16 ga.)	.068 (14 ga.)	.112 (11 ga.)	.112 (11 ga.)	.112 (11 ga.)
16″ to 20″	12	.044 (18 ga.)	.068 (14 ga.)	.068 (14 ga.)	.068 (14 ga.)	.068 (14 ga.)	.055 (16 ga.)	.068 (14 ga.)	.097 (12 ga.)	.097 (12 ga.)	.097 (12 ga.)

Chapter 12

COOLING

General

Sec. 1201. (a) **Scope.** Cooling systems and cooling units shall conform to the requirements of this chapter and to the applicable requirements of Part IV, Refrigeration.

(b) **Cooling Coils with Furnaces.** Cooling coils installed as a portion of or in connection with a warm-air furnace shall also be arranged to comply with the provisions of Chapter 7.

(c) **Use of Group 2 Refrigerants.** Direct refrigerating systems containing Group 2 refrigerants shall not serve an air-cooling or air-conditioning system used for human comfort.

(d) **Clearance from Ground Under Floors.** When cooling equipment other than ducts and piping is suspended from the under-floor construction, a clearance of at least 6 inches shall be provided between the base of the equipment and the ground.

Access

Sec. 1202. (a) **Cooling Units.** Except for piping, ducts and similar equipment that does not require servicing or adjusting, an unobstructed access and passageway not less than 2 feet in width by 6 feet 6 inches in height shall be provided to cooling units.

> **EXCEPTION:** The access opening to a cooling unit located in an attic space may be reduced to 30 inches in length and width, provided the unit can be replaced from this opening or another opening into this space or area.

(b) **Filters, Fuel Valves and Air Handlers.** An unobstructed access space not less than 24 inches in width and 30 inches in height shall be provided to filters, fuel-control valves and air-handling units. Refrigerant and brine piping control valves shall be accessible.

> **EXCEPTION:** An access opening from the unobstructed access space which opens directly to such equipment may be reduced to 15 inches in the least dimension if the equipment can be serviced, repaired and replaced from this opening without removing permanent construction.

(c) **Refrigeration Machinery Room Installations.** Access to equipment located in a refrigeration machinery room shall comply with Section 1507.

(d) **Roof or Exterior Wall Installations.** In addition to the applicable provisions of this section, access to a cooling unit or cooling system compressor located on a roof or on an exterior wall of a building shall be provided as required for furnaces in Section 710 of this code.

(e) **Attic or Furred Space Installations.** Access to and working platforms for cooling units or cooling system compressors located in an attic or furred space shall be provided as for furnaces in Section 708 of this code.

Lighting in Concealed Spaces

Sec. 1203. When access is required to equipment located in an under-floor space, attic or furred space, a permanent electric light outlet and lighting fixture shall be installed at or near the equipment. The light shall be controlled by a switch located at the required passageway opening.

> **EXCEPTION:** Lighting fixtures need not be installed when the fixed lighting for the building will provide sufficient light for safe servicing of the equipment.

Working Space

Sec. 1204. Equipment requiring access thereto, as specified in Section 1202, shall be provided with an unobstructed space on the control or servicing side of the equipment of not less than 30 inches in depth and 6 feet 6 inches in height. (**Note:** Also see the Electrical Code for working space requirements about electrical equipment.)

> **EXCEPTION:** The height of the working space may be reduced to 30 inches for an air-handling unit, air filter or refrigerant and brine-piping control valves.

Working space for equipment located in a machinery room shall comply with Section 1507.

Condensate Control

Sec. 1205. When a cooling coil or cooling unit is located in an attic or furred space where damage may result from condensate overflow, an additional watertight pan of corrosion-resistant metal shall be installed beneath the cooling coil or unit to catch the overflow condensate due to a clogged primary condensate drain, or one pan with a standing overflow and a separate secondary drain may be provided in lieu of the secondary drain pan. The additional pan or the standing overflow shall be provided with a drain pipe, minimum $^3/_4$-inch nominal pipe size, discharging at a point which can be readily observed. This requirement is in addition to the requirements for condensate waste piping set forth in Section 510 of this code.

Return Air and Outside Air

Sec. 1206. (a) **Source.** A cooling unit shall be provided with outside air, return air, or both. Cooling systems regulated by this code and designed to replace required ventilation shall be arranged to discharge into the conditioned space not less than the amount of outside air specified in the Building Code.

(b) **Prohibited Sources.** The outside and return air for a cooling system or cooling unit shall not be taken from the locations specified in Section 706 (f) as a prohibited source of air for a heating system.

(c) **Return-air Limitation.** Return air from one dwelling unit shall not be discharged into another dwelling unit through the cooling system.

(d) **Air Velocity.** Cooling systems shall be designed and constructed so that air velocity through filters does not exceed the filter manufacturer's recommendation. Filters shall be installed in other than portable cooling units.

(e) **Screen.** Required outside-air inlets shall be covered with screen having 1/4-inch openings.

> **EXCEPTION:** An outside-air inlet serving a nonresidential portion of a building may be covered with screen having openings larger than 1/4 inch but not larger than 1 inch.

Chapter 13

EVAPORATIVE COOLING SYSTEMS

General

Sec. 1301. Evaporative cooling systems shall comply with this chapter.

Except for Subsections 1206 (d) and (e), evaporative cooling systems shall be provided with outside air as specified for cooling systems in this code.

Air ducts and fire dampers which are a portion of an evaporative cooling system shall comply with this code.

Location

Sec. 1302. Evaporative cooling systems shall be installed so as to minimize the probability of damage from an external source.

Access, Inspection and Repair

Sec. 1303. Evaporative coolers shall be accessible for inspection, service and replacement without removing permanent construction.

Installation

Sec. 1304. An evaporative cooler supported by the building structure shall be installed on a substantial level base and shall be secured directly or indirectly to the building structure by suitable means to prevent displacement of the cooler.

Modifications made to the supporting framework of buildings as a result of the installation shall be in accordance with the requirements of the Building Code. Openings in exterior walls shall be flashed in an approved manner in accordance with the requirements of the Building Code.

An evaporative cooler supported directly by the ground shall be isolated from the ground by a level concrete slab extending not less than 3 inches above the adjoining ground level.

An evaporative cooler supported on an above-ground platform shall be elevated at least 6 inches above adjoining ground level.

Part IV

REFRIGERATION

Chapter 14

ABSORPTION REFRIGERATING EQUIPMENT

General

Sec. 1401. In addition to other provisions of this code, absorption equipment shall comply with the requirements of this chapter.

Approval of Equipment

Sec. 1402. Each absorption unit shall be approved for safe use based upon applicable nationally recognized standards.

Labels and Instructions

Sec. 1403. Fuel-burning absorption systems shall bear a label containing the following information:

1. Manufacturer's name.
2. Model number.
3. Amount and type of refrigerant.
4. Factory test pressures or pressures applied.
5. Normal Btu/h input rating.
6. Minimum Btu/h input rating for units having step or automatic modulating controls.
7. Cooling capacity in Btu/h.
8. Type of fuel.
9. Symbol of an approved agency certifying compliance of the equipment with recognized standards.
10. Instructions for the lighting, operation and shutdown of the system.

An absorption system shall be installed to conform to the conditions of its listing and to the requirements of this code. The installer shall leave the manufacturer's installation and operating instructions attached to the unit.

Location

Sec. 1404. Fuel-burning absorption systems shall not be installed in the following locations:

1. In any room or space less than 12 inches wider than the units installed therein, with a minimum clear working space of not less than 3 inches along the sides, back and top of the unit.

   EXCEPTION: A replacement absorption system occupying the same or lesser floor area may be installed in the same location as the existing absorption system, provided the replacement does not violate other provisions of this code.

2. In a hazardous location.
3. In a surgical operating room or medical treatment room.

4. In an occupancy, unless separated by fire-resistive construction from the rest of the building as required by the special hazards sections of Part III of the Building Code.
5. In Group R, Division 1 Occupancies, unless separated from such occupancy by not less than a one-hour fire-resistive occupancy separation.

   EXCEPTION: A separation shall not be required for equipment serving only one dwelling unit.
6. In a room used or designed to be used as a bedroom, bathroom, closet or in any enclosed space with access only through such room or space.

Absorption systems containing a Group 2 refrigerant shall not be located in any buildings unless installed within a refrigeration machinery room as provided in Chapter 15.

Absorption systems containing more than 20 pounds of a Group 2 refrigerant shall be located not less than 20 feet from any door, window or ventilating air inlet to a building.

> **EXCEPTION:** This distance may be reduced, provided the required pressure-relief device is arranged to discharge the refrigerant in compliance with Section 1517.

Absorption systems and portions thereof shall not be located in an elevator shaft, dumbwaiter shaft or a shaft having moving objects therein, nor in a location where it will be subject to mechanical damage.

Installation

Sec. 1405. Fuel-burning absorption systems shall be installed to conform with the conditions of listing and the manufacturer's installation instructions.

Fuel-burning absorption systems located outside of a building shall be completely enclosed in a weatherproof housing unless approved for outdoor installation. The housing, when constructed of metal, shall have a thickness of not less than 0.024-inch (No. 24 gage) galvanized sheet steel or aluminum not less than No. 22 B. & S. gage supported on a substantial metal frame. The housing shall be not larger than necessary to properly cover and provide a minimum 6-inch clearance around the unit or units enclosed therein, including all controls and draft diverters.

An absorption system supported from the ground shall rest on a concrete slab extending at least 3 inches above the adjoining ground level.

An absorption system shall be equipped with a factory-installed pressure-relief device, either a fusible plug, a rupture member or a pressure-relief valve.

Refrigerant piping and fittings, brine piping and fittings, which during normal operation could reach a surface temperature below the dew point of the surrounding air and which are located in spaces or areas where condensation could cause a safety hazard to the building occupants, structure, electrical equipment or other equipment, shall be protected to prevent such damage.

Access, working space and working platforms for absorption units and absorption systems shall be provided as for cooling units and cooling systems as set forth in Chapter 12 of this code.

Chapter 15

MECHANICAL REFRIGERATING EQUIPMENT

Scope

Sec. 1501. In addition to the general requirements of Chapter 5, mechanical refrigerating systems and equipment shall conform to the requirements of this code.

The listing and label of an approved agency, which is attached to the equipment, may be accepted as evidence that the equipment complies with applicable nationally recognized standards.

Refrigerating systems and equipment, including the replacement of parts and alterations, shall comply with the provisions of this chapter.

Refrigerants

Sec. 1502. The refrigerant used shall be of a type listed in Section 1503 unless the building official finds that a proposed refrigerant is no more hazardous to life, limb, health or property than the type listed.

Classification of Refrigerants

Sec. 1503. (a) **Group 1.** The following shall be classified as Group 1 refrigerants:

REFRIGERANT DESIGNATION	NAME	CHEMICAL FORMULA
R-11	Trichlorofluoromethane	CCl_3F
R-12	Dichlorodifluoromethane	CCl_2F_2
R-13	Chlorotrifluoromethane	$CClF_3$
R-13B1	Bromotrifluoromethane	$CBrF_3$
R-14	Tetrafluoromethane	CF_4
R-21	Dichlorofluoromethane	$CHCl_2F$
R-22	Chlorodifluoromethane	$CHClF_2$
R-30	Dichloromethane (Methylene chloride)	CH_2Cl_2
R-113	Trichlorotrifluoroethane	CCl_2FCClF_2
R-114	Dichlorotetrafluoroethane	$CClF_2CClF_2$
R-115	Chloropentafluoroethane	$CClF_2CF_3$
R-C318	Octafluorocyclobutane	C_4F_8
R-500	Dichlorodifluoromethane, 73.8% and Ethylidene Fluoride, 26.2%	CCl_2F_2/CH_3CHF_2
R-502	Chlorodifluoromethane, 48.8% and Chloropentafluoroethane, 51.2%	$CHClF_2/CClF_2CF_3$
R-744	Carbon dioxide	CO_2

(b) **Group 2.** The following shall be classified as Group 2 refrigerants:

REFRIGERANT DESIGNATION	NAME	CHEMICAL FORMULA
R-40	Methyl chloride	CH_3Cl
R-611	Methyl formate	$HCOOCH_3$
R-717	Ammonia	NH_3
R-764	Sulphur dioxide	SO_2

General

Sec. 1504. (a) **Supports.** Supports for compressors and condensing units shall be designed to safely carry the equipment. Supports from buildings or parts of buildings that are of noncombustible construction shall be noncombustible.

A compressor or portion of a condensing unit supported from the ground shall rest on a concrete or other approved base extending at least 3 inches above the adjoining ground level.

(b) **Access.** An unobstructed access opening and passageway at least 24 inches in the least dimension shall be provided and maintained to compressor, unless otherwise specified by this code.

(c) **Prohibited Locations.** Refrigerating systems and portions thereof shall not be located in an elevator shaft, dumbwaiter shaft or a shaft having moving objects therein, nor in a location where it will be subject to mechanical damage.

Electrically energized components of refrigerating systems shall not be placed in a hazardous location unless listed for such location.

(d) **Ventilation of Rooms Containing Condensing Units.** Rooms or spaces, other than a refrigeration machinery room complying with the requirements of this chapter, in which any refrigerant-containing portion of a condensing unit is located, shall be provided with one of the following means of ventilation:

1. Permanent gravity ventilation openings of not less than 2 square feet net free area opening directly to the outside of the building or extending to the outside of the building by continuous ducts.
2. A mechanical exhaust system arranged to provide a complete change of air in such room or space at least every 20 minutes and to discharge to the outside of the building.

EXCEPTION: This paragraph shall not apply to a portion of a condensing unit in a room or space if the cubical content exceeds 1000 cubic feet per horsepower of the unit or where such room or space has permanent gravity ventilation openings of 2 square feet minimum total area to other rooms or spaces exceeding 1000 cubic feet per horsepower.

(e) **Compressors Near Exits.** Refrigerant compressors of more than five horsepower rating shall be located at least 10 feet from an exit in a Group A, B, Division 2, E, I or R, Division 1 Occupancy unless separated by a one-hour fire-resistive occupancy separation.

(f) **Condensate Control.** Piping and fittings which convey brine, refrigerant or coolants which during normal operation could reach a surface temperature below the dew point of the surrounding air and which are located in spaces or areas where condensation could cause a hazard to the building occupants, structure, electrical or other equipment shall be protected to prevent such damage.

Group 1 Refrigerants

Sec. 1505. (a) **General.** Condensing units or combinations of refrigerant interconnected condensing units totaling 100 or more horsepower rating which contain a Group 1 refrigerant shall be enclosed in a refrigeration machinery room.

> **EXCEPTION:** The requirement shall not apply to: 1. A condensing unit located outside of a building or on the roof of a building and not less than 20 feet from a door, window or ventilating air opening in a building.
>
> 2. A condensing unit located in a building used exclusively for ice making or cold storage together with the usual accessory rooms in connection therewith.
>
> 3. A Group B, Division 2 or 4 Occupancy, if the quantity of refrigerant does not exceed 30 pounds for each 1000 cubic feet of space in the room in which the condensing unit is located.

(b) **Direct Systems.** The maximum quantity of a Group 1 refrigerant in a direct system in occupancies other than Group I shall not exceed that set forth in Table No. 15-A.

Direct systems in Group I Occupancies shall be limited to systems each containing not more than 50 percent of the permissible quantities of Group 1 refrigerants set forth in Table No. 15-A. When the refrigerant-containing parts of a system are located in one or more enclosed spaces, the cubical content of the smallest enclosed humanly occupied space other than the room in which the refrigeration equipment is located, shall be used to determine the permissible quantity of refrigerant in the system. When a refrigerating system has evaporator coils serving individual stories of a building, the story having the smallest volume shall be used to determine the maximum quantity of refrigerant in the entire system.

When the evaporator is located in an air-duct system, the cubical content of the smallest humanly occupied enclosed space served by the air-duct system shall be used to determine the permissible quantity of refrigerant in the system.

> **EXCEPTION:** If the air flow to any enclosed space served by a portion of an air-duct system cannot be shut off or reduced below one-quarter of its maximum, the cubical contents of the entire space served by that portion of the air-duct system may be used to determine the permissible quantity of refrigerant in the system.

A system containing more than the quantity of a Group 1 refrigerant permitted by the foregoing provisions shall be of the indirect type.

Group 2 Refrigerants

Sec. 1506. A mechanical refrigerating system or unit refrigerating system containing a Group 2 refrigerant shall not be located within a building unless all refrigerant-containing portions of the system are enclosed in a refrigeration machinery room. Such systems when installed outside of a building shall be located at least 20 feet from an exit door, window or ventilating-air inlet in a building.

EXCEPTION: This shall not apply to a building used exclusively for ice making, cold storage or for the manufacturing or processing of food or drink, provided the occupant load does not exceed one person per 100 square feet of floor area served by such system. Portions of refrigerating systems containing Group 2 refrigerants shall not be located in an exit.

Direct refrigeration systems containing Group 2 refrigerants shall not serve an air-cooling or air-conditioning system used for human comfort.

Refrigeration Machinery Rooms

Sec. 1507. Required refrigeration machinery rooms shall be of at least one-hour fire-resistive construction, provided with doors complying with the Uniform Building Code Section 3305 (h) and having no other openings that will permit the passage of escaping refrigerant to other parts of the building.

There shall be no direct opening between a refrigeration machinery room containing a Group 2 refrigerant and a room or space in which there is an open flame, spark-producing device or heating surface hotter than 800°F. A refrigeration machinery room containing Group 2 refrigerants shall have at least two means of egress located at least one-fifth the perimeter of the room apart. Exit doors shall be at least 3 feet by 6 feet 8 inches.

Refrigeration machinery rooms containing Group 1 refrigerants shall have an exit door at least 3 feet by 6 feet 8 inches.

A refrigeration machinery room door shall open in the direction of egress.

A refrigeration machinery room shall have an area of at least 50 square feet.

An unobstructed working space at least 2 feet 6 inches in width and at least 7 feet in height shall be provided around two adjacent sides of all moving machinery in a refrigeration machinery room.

Emergency Refrigeration Machinery Room Ventilation

Sec. 1508. Refrigeration machinery rooms shall be provided with means of emergency ventilation to the outside of the building. Such ventilation shall be either of the following:

1. A separate and individual exhaust system of ventilation serving no other area and having the capacity to provide a complete change of air in such room at least once every five minutes and discharge to the outside of the building at a location not less than 20 feet from any exterior door, window or ventilation air inlet in any building. Provisions shall be made for makeup air to replace that being exhausted. Each exhaust ventilation system shall be controlled by a readily accessible emergency ventilation switch located within 2 feet of the switch specified in Section 1509, and the switch shall be labeled to comply with Section 1519.

2. Mechanical ventilation or gravity ventilation openings to the outside of the building shall be sized in accordance with Table No. 15-B based on accumulated horsepower in the rooms with refrigeration units.

Gravity openings shall be so installed that approximately one half of the required area is located within 12 inches of the ceiling and one half of the required area is located within 12 inches of the floor of the room. Every portion of the lower opening shall be horizontal or slope downward from the opening in the refrigeration machinery room to the exterior of the building at or above the adjacent ground level.

Equipment in a Refrigeration Machinery Room

Sec. 1509. Combustion air shall not be taken from a refrigeration machinery room. [See Section 603 (c).]

Electrical equipment or electrical control or control panel other than listed below shall not be located in a refrigeration machinery room:

1. Lights and receptacles.
2. Machinery room exhaust fans and blowers.
3. A refrigerating condensing unit or portion thereof.
4. Circulating pumps for condensers, cooling towers or cooling coils.
5. Air compressors serving only automatic controls within the refrigerating or cooling system.
6. Electrically operated valves for the control of a refrigerant or for the control of the circulation of a cooling fluid.
7. Blowers and fans for cooling towers or for condensers.
8. An electric control or control panel for the above items.

A readily accessible single emergency refrigeration control switch shall be provided to shut off electrically operated machinery in a refrigeration machinery room, except the exhaust ventilation system complying with Section 1508. Such switch shall be controlled from a point outside of, and within 10 feet of, the required exit from the refrigeration machinery room it serves, and the switch shall be labeled to comply with Section 1519. For other requirements concerning the location of this switch, see the Electrical Code.

Refrigerant Piping, Containers and Valves

Sec. 1510. Materials used in the construction and installation of refrigerating systems shall be suitable for the refrigerant in the system, and no material or equipment shall be installed which will deteriorate due to the chemical action of the refrigerant or the oil, or combination of both.

Copper and brass refrigerant piping valves, fittings and related parts used in the construction and installation of refrigerating systems shall be approved for such use. (See "Refrigeration Piping" in the list of reference standards in Appendix C of this code.)

Iron and steel refrigerant piping shall comply with the requirements of U.M.C. Standard No. 15-1. Pipe more than 2 inches iron pipe size shall be electric resistance welded, or seamless pipe.

Pipe subject to working pressure in excess of 300 pounds per square inch shall have a minimum wall thickness not less than that specified in U.M.C. Standard No. 15-1; Table No. 15-1-A for Schedule 80 pipe.

Iron or steel refrigerant piping 1 1/2-inch nominal size and smaller and containing liquid refrigerant shall have a minimum wall thickness not less than that specified in U.M.C. Standard No. 15-1; Table No. 15-1-A for Schedule 80 pipe, or Schedule 40 pipe if all field joints are welded.

Brass pipe, copper pipe and copper tubing shall conform to the requirements of U.M.C. Standard No. 15-2. Brass pipe and copper pipe subject to working pressures exceeding 250 pounds per square inch shall be at least extra-strong pipe. Copper water tubing used for refrigerant piping shall be Type K or L and shall be free from scale and dirt.

Soft annealed copper tubing regulated by this section shall be limited to 1 3/8-inch nominal size. No mechanical joint shall be made on material larger than 3/4-inch nominal size.

Soft annealed copper tubing conveying refrigerant shall be enclosed in iron or steel piping and fittings or in conduit, molding or raceway which will properly protect such tubing against mechanical injury from an exterior source.

> **EXCEPTION:** The requirements of this section shall not apply to: 1. Tubing entirely within a refrigerator or tubing within 5 feet of a refrigerant compressor where so located that it is not subject to external injury.
>
> 2. Tubing serving a dwelling unit, when such tubing contains Group 1 refrigerant and is placed in locations not subject to damage from an external source.

Erection of Refrigerant Piping

Sec. 1511. Piping and tubing shall be installed so as to prevent excessive vibration and strains at joints and connections.

Piping and tubing shall be securely fastened to a permanent support within 6 feet following the first bend in such tubing from the compressor, and within 2 feet of each other bend or angle. Piping and tubing shall be supported at points not more than 15 feet apart.

Refrigerant piping crossing an open passageway in a building shall be at least 7 1/2 feet above the floor unless against the ceiling of such space.

Refrigerant piping and tubing shall be installed so that it is not subject to damage from an external source.

Refrigerant piping and joints connected and installed in the field shall be exposed to view for visual inspection and acceptance by the building official prior to being covered or enclosed.

> **EXCEPTION:** This shall not apply to soft annealed copper tubing enclosed in iron or steel piping conduit, molding or raceway, provided there are no fittings or joints concealed therein.

Copper tubing containing other than a Group 1 refrigerant shall not be located in a public hallway, lobby or stairway of a building unless enclosed in iron or steel piping and fittings or in metal rigid conduit.

> **EXCEPTION:** This section shall not apply to hard-drawn copper tubing installed in locations where not subject to injury from an external source.

Iron or steel refrigerant piping placed underground shall be coated with sufficient asphalt paint or equal to inhibit corrosion.

Iron or steel pipe joints shall be threaded, flanged or welded. Threaded joints shall be of an approved type. (See Pipe Threads in Reference Standards, Appendix C of this code.) Exposed threads shall be tinned or otherwise coated to inhibit corrosion.

Welds shall be of an approved type. (See Refrigeration Piping in Reference Standards, Appendix C of this code.)

Copper or brass pipe of iron pipe size shall be threaded, flanged or brazed.

Tubing joints and connections shall be flared, lapped or swaged brazed joints.

> **EXCEPTION:** Soldered joints may be used to connect a valve located outside of an air-conditioning duct or plenum to adjoining tubing in a refrigerating system containing Group 1 refrigerant other than carbon dioxide.

Refrigerant Containers

Sec. 1512. A refrigerant container or evaporator which is not a part of listed equipment shall be constructed in accordance with approved standards.

Refrigerant Control Valves

Sec. 1513. Stop valves shall be installed in the refrigerant piping of refrigerating systems at the following locations:

1. At each inlet and outlet of every positive-displacement-type compressor.
2. At each refrigerant outlet from a receiver.
3. At each refrigerant inlet of a pressure vessel containing liquid refrigerant and having an internal gross volume exceeding 3 cubic feet, which vessel is a portion of a refrigerating system equipped with a positive-displacement-type of compressor.

Stop valves installed in refrigerant lines composed of copper tubing 3/4-inch or less outside diameter shall be securely and independently supported by tubing or piping connected to such valve.

Pressure-limiting Device

Sec. 1514. A pressure-limiting device shall be installed on a positive displacement refrigerant compressor which is a portion of:

1. A refrigerating system containing Group 2 refrigerant.
2. An air-cooled refrigerating system containing Group 1 refrigerant, of 10 horsepower or more rating.
3. A water-cooled refrigerating system containing Group 1 refrigerant, of three horsepower or more rating.

A pressure-limiting device shall stop the action of the compressor it serves at a pressure not exceeding that indicated in Table No. 15-C for the refrigerant.

A stop or shutoff valve shall not be placed between a pressure-limiting device required by this section and the compressor it serves.

Pressure-relief Valves—Compressors

Sec. 1515. The following compressors of the positive-displacement-type shall be equipped with a pressure-relief valve:

1. A Group 1 refrigerant compressor of 20 or more horsepower rating which is a portion of a refrigerating system operating at a pressure exceeding 15 pounds per square inch in the high-pressure side of the system.
2. A compressor which is a portion of a refrigerating system containing a Group 2 refrigerant.

> **EXCEPTION:** The requirements of this section shall not apply to a compressor listed without such relief valve.

A pressure-relief valve shall be connected to the refrigerant discharge side of the compressor it serves, between such compressor and a stop valve.

A pressure-relief valve required by this section shall discharge into the low-pressure side of the refrigerating system it serves or discharge to the outside of the building as required by this code. A pressure-relief device that discharges from the high-pressure side of the refrigerating system into the low-pressure side must be of a type that is not appreciably affected by back pressure.

A pressure-relief valve required by this section shall be set to function at a pressure not exceeding the pressure set forth in Table No. 15-C corresponding to the portion of the refrigerating system in which such valve is located and the kind of refrigerant contained in the system.

A stop or shutoff valve shall not be installed between a pressure-relief valve required by this section and the compressor it serves.

A pressure-relief valve, required by this section, that terminates outdoors, shall discharge at a location at least 15 feet above the adjoining ground level and at least 20 feet from a window, ventilation opening or exit from a building.

Pressure-relief Devices—Pressure Vessels

Sec. 1516. A pressure vessel over 6 inches in diameter which may be shut off by valves from other parts of the system shall be equipped with a pressure-relief device or devices complying with requirements of this code.

Pressure vessels of 3 cubic feet or less gross volume containing liquid refrigerant shall be equipped with either a pressure-relief valve, fusible plug or rupture member, provided, however, that a fusible plug is permitted only on the high-pressure side of the refrigerating system.

Pressure vessels having a gross volume greater than 3 cubic feet shall be equipped with a pressure-relief valve or rupture member.

Pressure-relief Device Requirements

Sec. 1517. Except as provided in this section, a pressure-relief device for a refrigerant vessel shall be set to function at a pressure not exceeding that set forth in Table No. 15-C for the portion of the system to which the device is connected and for the refrigerant in the container.

Pressure-relief devices may be set to start to function at a pressure not to exceed the design working pressure of the pressure vessel as determined by the manufacturer and stamped on the pressure vessel.

The minimum required rated discharge capacity of the pressure-relief device or fusible plug for a refrigerant-containing vessel shall be determined by the following:

$$C = f \times D \times L$$

WHERE:

C = minimum required discharge capacity of the relief device in pounds of air per minute.

D = outside diameter of the vessel in feet.

L = outside length of the vessel in feet.

f = factor depending upon kind of refrigerant as follows:

Kind of Refrigerant	Value of *f*
Ammonia	0.5
R-12, R-22 and R-500	1.6
R-502	2.2
Other refrigerants	1.0

A pressure-relief device shall bear thereon:

1. Name or trademark of the manufacturer of such device.
2. The discharge or bursting pressure setting of the device expressed in pounds per square inch gage.
3. The minimum nominal diameter of the discharge outlet or opening of such valve.
4. The discharge capacity of the pressure-relief device in pounds of air per minute.

A pressure-relief valve shall be set and sealed by the manufacturer of the valve or such valve may be set and sealed in a laboratory approved by the building official, provided such valve is properly relabeled.

A pressure-relief device required by this section for a pressure vessel of 3 cubic feet gross volume or more containing Group 1 refrigerant or a pressure vessel containing any Group 2 refrigerant shall discharge to the atmosphere at a location not less than 15 feet above the adjoining ground level and at least 20 feet from a window, ventilation opening or exit from a building.

A pressure-relief device required by this section shall be connected as close as practicable to the refrigerant container or evaporator it serves and above the refrigerant level in such container or evaporator.

A stop or shutoff valve shall not be placed between a pressure-relief device required by this section and the pressure vessel it serves.

The discharge pipe from pressure-relief devices shall be not less than the size of the relief-device outlet. The discharge from more than one relief device may be run into a common header, the area of which shall be at least the sum of the areas of the pipes connected thereto. When the length of the discharge piping exceeds 50 feet, piping shall be increased one pipe size.

Piping and fittings used as relief-device discharge piping shall conform to Section 1510 of this code.

Manual Discharge of Carbon Dioxide or Group 2 Refrigerants

Sec. 1518. (a) **Discharge to Atmosphere.** A refrigerating system located in a building and containing carbon dioxide or a Group 2 refrigerant shall be equipped with means for manual discharge of the refrigerant to the atmosphere. Such discharge system shall comply with the following requirements:

1. A discharge pipe shall be provided above the liquid refrigerant level from both the high- and low-pressure sides of the system and the pipes shall extend into an emergency refrigerant control box complying with this section. Each discharge pipe shall have a minimum nominal diameter of 1 inch.

2. A readily accessible stop valve and a high-pressure gage shall be installed on each discharge pipe within the emergency refrigerant control box. The gage shall be located ahead of each stop valve and the valves shall have the same capacity as the discharge pipe it serves. A permanent label shall be attached to each valve reading "Discharge Valve to Atmosphere," and shall indicate the side of the system to which it is connected.

3. Each discharge pipe shall extend from the discharge side of the valve to a common pipe having a minimum nominal diameter of 1 inch. This common pipe shall terminate outside the building, not less than 6 feet above the highest structure on the building and at least 20 feet from any window, ventilation opening or exit from a building. The outlet opening shall be capped with a low-pressure rupturable diaphragm, such as a heavy foil disk in a pair of flanges, or equivalent.

4. A stop valve, which could prevent manual discharge of the refrigerant to the atmosphere, shall not be located between the emergency refrigerant discharge valves and the sides of the system they are serving.

(b) **Release from High-pressure Side.** A refrigerating system required to have means of manual discharge of its refrigerant to the atmosphere also shall be equipped with manual means of releasing the refrigerant from the high-pressure side of the system to the low-pressure side. This manual means shall comply with the following requirements:

1. The high- and low-pressure sides of the system shall be interconnected with a pipe having a minimum nominal diameter of 1 inch. This interconnection shall be made above the liquid refrigerant level.

2. A readily accessible manual stop valve shall be installed in this interconnecting pipe, and the valve shall be located within the emergency refrigerant control box. This valve shall have the same capacity as the pipe connected thereto.

3. A permanent label shall be attached to this valve reading "High- to Low-pressure Control Valve."

4. A stop valve, which could prevent releasing of the refrigerant from the high-pressure side of the system to the low-pressure side, shall not be installed in this interconnecting pipe between the high- and low-pressure side of the system.

(c) **Emergency Refrigerant Control Box.** An emergency refrigerant control box shall be located outside of the building on a street front or shall be equally accessible and shall be not more than 6 feet above the sidewalk or adjoining ground level. This box shall be of iron or steel not less than 0.055-inch (No. 16 gage) thickness and provided with a hinged cover and lock. Such box shall be provided with a permanent label on the outside cover reading "Emergency Refrigerant Control Box," and the name of the refrigerant in the system.

Piping, valves, fittings and related parts required to be installed to comply with this section shall conform to Section 1510 of this code.

Labels

Sec. 1519. In addition to labels required elsewhere in this code, a refrigerating system shall be provided with labels complying with the requirements of this section.

A condenser, receiver, absorber, accumulator and similar equipment of more than 3 cubic feet gross volume and containing Group 2 refrigerant shall be equipped with a permanent label setting forth the type of refrigerant in such vessel. A vessel having a gross volume of more than 10 cubic feet and containing Group 1 refrigerant shall be equipped with a permanent label setting forth the type of refrigerant in such vessel.

A manifold or distributing panel shall have a permanent label setting forth the refrigerating equipment controlled by each valve on such panel.

Exposed refrigerant piping shall be labeled at intervals not greater than 30 feet plus a label in each area through which the piping extends specifying the refrigerant in such piping.

> **EXCEPTION:** The provisions of this section shall not apply to: 1. Piping in brine tanks.
>
> 2. Piping in that portion of a building used exclusively for ice making, cold storage or for the processing of material by means of refrigeration.

A refrigerating system which is required to be located in a machinery room shall be equipped with permanent labels having letters not less than 1/2 inch in height designating the following equipment:

1. The main power disconnect switch for such refrigerating system.
2. A remote control device for the main power switch.
3. The main shutoff valve for each liquid refrigerant container.
4. A pressure-limiting device and pressure-relief device located outside the room or space in which the refrigerant container it serves is located.

An exhaust ventilating system control switch required to be installed to comply with Section 1508 shall have a permanent label reading "Emergency Ventilation Switch."

A control switch provided to shut off all electrically operated machinery in a refrigeration machinery room, as required by Section 1509, shall have a permanent label reading "Emergency Refrigeration Switch."

In a refrigeration machinery room and for a direct refrigerating system of more than 10 horsepower there shall be placed a permanent sign within 10 feet of the compressor giving the following information:

1. Name of contractor installing equipment.
2. Kind of refrigerant in system.
3. Amount of refrigerant in system.

A pressure-relief device required by this code shall be labeled to comply with Section 1517.

Testing of Refrigerating Equipment

Sec. 1520. Refrigerant-containing portions of a field-assembled refrigerating system intended or installed to operate at a pressure in excess of atmospheric pressure shall be subjected to a test pressure equal to or greater than the pressure set forth in Table No. 15-D for the kind of refrigerant in the system.

Pressure tests required by this section shall be equal to or greater than the lowest setting of a pressure-relief device installed in the side of the system it is protecting.

The requirements of this section shall not apply to:

1. A refrigerating system containing 20 pounds or less of Group 1 refrigerant.
2. Safety devices, pressure gages, compressors and control mechanisms which have been factory tested.
3. Pressure vessels constructed in accordance with approved standards.

The test pressure applied to a refrigerant container shall not exceed two and one half times the design working pressure stamped on the container.

The high-pressure test for a refrigerating system intended to contain a refrigerant not listed in Table No. 15-C shall be equal to or greater than the saturated vapor pressure of such refrigerant at a temperature of 150°F. The test pressure shall be at least 30 pounds-per-square-inch gage.

A refrigerating system installed to operate at a pressure below atmospheric pressure shall maintain a partial vacuum in the system equal to the pressure of a column of mercury at least 20 inches in height.

A refrigerating system shall sustain the test pressure specified in this section for a period of at least 10 minutes after the pressure-imposing equipment has been cut off or disconnected.

A pressure test for those portions of a refrigerating system to contain ammonia or carbon dioxide shall be made with air or dry gas.

Refrigerating systems shall not be tested with oxygen.

Brine piping may be tested with air, water or dry gas.

Brine piping which is a portion of a refrigerating system shall be tested at 100 psi for a period of 10 minutes.

Additional tests of a refrigerating system may be demanded by the building official when deemed necessary to ensure the safety of such system.

A test required by this section shall be conducted by the owner or contractor in the presence of the building official.

TABLE NO. 15-A—MAXIMUM PERMISSIBLE QUANTITIES OF GROUP 1 REFRIGERANT FOR DIRECT SYSTEMS

REFRIGERANT DESIGNATION	NAME	MAXIMUM QUANTITY IN LB. PER 1000 CU. FT. OF HUMANLY OCCUPIED SPACE
R-11	Trichlorofluoromethane	35
R-12	Dichlorodifluoromethane	31
R-13	Chlorotrifluoromethane	27
R-13B1	Bromotrifluoromethane	38
R-14	Tetrafluoromethane	23
R-21	Dichlorofluoromethane	13
R-22	Chlorodifluoromethane	22
R-30	Dichloromethane (Methylene chloride)	6
R-113	Trichlorotrifluoroethane	24
R-114	Dichlorotetrafluoroethane	44
R-115	Chloropentafluoroethane	40
R-C318	Octafluorocyclobutane	50
R-500	Dichlorodifluoromethane, 73.8% and Ethylidene Fluoride, 26.2%	26
R-502	Chlorodifluoromethane, 48.8% and Chloropentafluoroethane, 51.2%	30
R-744	Carbon dioxide	11

TABLE NO. 15-B
MINIMUM AIR DUCT NET AREAS AND OPENINGS

TOTAL HORSEPOWER[1]	MECHANICAL DISCHARGE OF AIR, cfm	MECHANICAL EXHAUST DUCT AREA (SQUARE FEET)	AREA OF GRAVITY OPENINGS TO THE OUTSIDE OF THE BUILDNG (SQUARE FEET)
6	150	¼	4
16	250	⅓	6
33	400	½	10
50	550	⅔	12½
66	680	⅔	14
83	800	1	15
100	900	1	17
133	1,100	1¼	20
166	1,275	1¼	22
200	1,450	1½	24
233	1,630	1½	26
266	1,800	2	28
300	1,950	2	30
333	2,050	2	31
416	2,250	2¼	33
500	2,500	2¼	37
583	2,700	2¼	38
667	2,900	2¼	40
833	3,300	2½	43
1,000	3,700	3	48
1,333	4,600	3¾	55
1,667	5,500	4½	62
2,000	6,300	5	68
2,333	7,200	5½	74
2,667	8,000	5¾	80
3,000	8,700	6¼	85
3,333	9,500	6½	90
4,000	10,900	7	100
4,667	12,200	7½	109
5,333	13,300	7¾	118
6,000	14,300	8	125
6,667	15,200	8¼	130
8,333	17,000	8¾	140
10,000	18,200	9	145
11,667	19,400	9¼	150
13,333	20,500	9½	155
15,000 or greater	21,500	9¾	160

[1] Table assumes 3 pounds of refrigerant per horsepower. Systems utilizing a different charge weight shall be corrected accordingly.

TABLE NO. 15-C—PRESSURES FOR UNLISTED EQUIPMENT

REFRIGERANT	COMPRESSOR PRESSURE LIMITING DEVICE OPERATING PRESSURE (In Pounds per Square Inch)	PRESSURE RELIEF VALVES AND DEVICES OPERATING PRESSURE (In Pounds per Square Inch)	
		High Pressure Side	Low Pressure Side
Ammonia	225	250	150
Carbon Dioxide	1200	1350	1000
Dichloroethylene	5	10	10
Dichloromethane (Refrigerant 1)	25	30	30
Ethyl Chloride	50	55	50
Trichloroethylene	25	30	30
Trichloromonofluoromethane (Refrigerant 11)	25	30	30
Dichlorodifluoromethane (Refrigerant 12)	160	225	125
Dichloromonofluoromethane (Refrigerant 21)	60	70	50
Monochlorodifluoromethane (Refrigerant 22)	245	300	245
Trichlorotrifluoroethane (Refrigerant 113)	25	30	30
Dichlorotetrafluoroethane (Refrigerant 114)	45	50	50
Methyl Chloride	170	200	125
Methyl Formate	25	30	30
Sulphur Dioxide	125	150	95
Refrigerant 500	160	225	125
Refrigerant 502	245	300	150

TABLE NO. 15-D—FIELD LEAK TEST PRESSURES IN PSI

REFRIGERANT	HIGH PRESSURE TEST	LOW PRESSURE TEST
Ammonia	300	150
Carbon Dioxide	1500	1000
Dichloroethylene	30	30
Dichloromethane (Refrigerant 1)	30	30
Ethyl Chloride	60	50
Trichloroethylene	30	30
Trichloromonofluoromethane (Refrigerant 11)	30	30
Dichlorodifluoromethane (Refrigerant 12)	235	140
Dichloromonofluoromethane (Refrigerant 21)	70	40
Monochlorodifluoromethane (Refrigerant 22)	300	150
Trichlorotrifluoroethane (Refrigerant 113)	30	30
Dichlorotetrafluoroethane (Refrigerant 114)	50	50
Methyl Chloride	210	120
Methyl Formate	50	50
Sulphur Dioxide	170	85
Refrigerant 500	225	125
Refrigerant 502	300	150

Chapter 16

STORAGE OF REFRIGERANTS

General

Sec. 1601. Refrigerants in excess of the amounts within an approved refrigeration system shall be stored in a refrigeration machinery room in their original approved containers and shall not exceed the amount contained in the system. The total amount stored shall not exceed 300 pounds.

> **EXCEPTION:** The provisions of this section shall not apply to a refrigerant in a scientific laboratory during tests and experiments nor to refrigerants in the actual process of manufacture.

When refrigerant is removed or withdrawn from a refrigerating system it shall be discharged into an approved shipping container except as provided in Section 1518.

A portable refrigerant container shall not be connected to a refrigerating system for a period longer than is necessary to charge or discharge the refrigerating system.

Chapter 17

COOLING TOWERS

General

Sec. 1701. Cooling towers shall comply with the requirements for roof structures as specified in the Building Code. See Uniform Building Code Chapter 36.

Cooling towers or evaporative condensers which are equipped with a positive water discharge to prevent excessive build-up of alkalinity and are used for water-cooled condensing units or absorption units shall discharge the water into an approved disposal system.

Water supply, waste, water, piping and connections shall comply with provisions of applicable codes and ordinances.

PART V

MISCELLANEOUS

Chapter 18

INCINERATORS

General

Sec. 1801. Incinerators for the reduction of refuse, garbage or other waste materials shall be installed in accordance with the provisions of this chapter. Materials and structural design shall meet the requirements of the Building Code.

Small Domestic Type

Sec. 1802. Incinerators of small uninsulated domestic type installed indoors shall be constructed, mounted, installed and vented according to the applicable requirements for room heating stoves burning solid fuel and room heaters burning liquid fuel as specified in Chapters 5, 6, 8 and 9 of this code, except that mounting shall be on a noncombustible and fire-resistive floor, and minimum clearances to combustible materials shall be 36 inches above, 48 inches in front and 36 inches in back and at sides. The requirements of this section also apply to incinerators installed as a part of other appliances.

Incinerators of small domestic type, or those that are a part of another appliance, which have been tested and approved by an approved agency and listed for installation on a combustible floor or with lesser clearances shall be installed in accordance with the conditions of their listing and shall be connected to a chimney complying with the requirements of Chapter 9.

> **EXCEPTION:** Existing unlined chimneys having at least 4-inch nominal brick walls may be used for the venting of domestic gas-fired freestanding incinerators when such chimneys meet the other requirements of this chapter and have been approved and inspected by the building official.

Outdoor incinerators of small domestic type and their location shall be approved.

Incinerators Using the Flue as a Refuse Chute

Sec. 1803. Incinerators in which no fuel other than normal refuse, except a gas flame or similar means to accomplish ignition, is used for combustion, and in which the chute and smoke flue are identical, shall have the enclosing walls of the combustion chamber constructed of clay or shale brickwork not less than 4 inches thick when there is a horizontal grate area of not more than 9 square feet and not less than 8 inches thick when there is a horizontal grate area exceeding 9 square feet and, in each case, a lining of firebrick not less than 4 inches thick, with an air space, in the case of the thicker wall, between the clay or shale brick and the firebrick sufficient to provide for expansion and contraction.

The combined chute and flue shall be constructed as required for incinerator chimneys in Chapter 37 of the Building Code. The chute and flue shall be constructed straight and plumb, and finished smooth on the inside. All flues shall terminate in a substantially constructed spark arrester having a mesh not exceeding 1/2 inch.

Firebrick shall be laid in fireclay mortar.

Service openings into the chute shall be equipped with approved self-closing hoppers so constructed that the openings are closed off while the hopper is being charged and no part will project into the chute or flue. The area of the service opening shall not exceed one third of the area of the chute or flue.

Commercial and Industrial Types

Sec. 1804. Commercial- and industrial-type incinerators designed to burn not more than 250 pounds of refuse per hour and having a horizontal grate area not exceeding 9 square feet shall have enclosing walls of the combustion chamber constructed of clay or shale brick not less than 8 inches thick, with a lining of firebrick not less than 4 inches thick, provided that the outer 4 inches of clay or shale brickwork may be replaced by a steel plate casing not less than 3/16 inch in thickness.

Commercial and industrial types of incinerators of a size designed to burn more than 250 pounds of refuse per hour and having a grate area exceeding 9 square feet shall have enclosing walls of the combustion chamber constructed of clay or shale brick not less than 8 inches thick with a lining of firebrick not less than 8 inches thick, provided that the outer 4 inches of clay or shale brickwork may be replaced by a steel plate casing not less than 3/16 inch in thickness.

Incinerators with their waste material bins or containers shall be located in a room or compartment used for no other purpose, or in a room devoted exclusively to boilers and heating plant. In either case such room shall be separated from the rest of the building by a one-hour fire-resistive occupancy separation.

The flue connections or breechings from the combustion chamber shall be constructed of 0.055-inch-thick (No. 16 U.S. gage) steel when they do not exceed 12 inches in diameter or greater dimension and of 0.097-inch-thick (No. 12 U.S. gage) steel when they exceed 12 inches in diameter or greatest dimension. In addition they shall be lined with firebrick laid in fireclay mortar not less than 2 1/2 inches thick when they are between 12 inches and 18 inches in diameter or greatest dimension, and not less than 4 1/2 inches thick when they are larger. If they lead into and combine with flue connections or breechings from other appliances, such other connections or breechings shall also be lined as required for direct flue connections, unless the cross-sectional area of the connection into which they lead is at least four times the area of the incinerator connection.

The clearance to woodwork or other combustible material or construction on all sides of flue connections or breechings shall be not less than 36 inches, provided that clearances may be reduced as set forth in Table No. 5-B.

Refuse chutes shall not feed directly to the combustion chamber but shall discharge into a room or bin enclosed and separated from the incinerator room by floors, ceilings and walls of not less than two-hour fire-resistive construction. The opening through which material is transferred from such room or bin to the incinerator room shall be equipped with a fire assembly having a three-hour fire-resistive rating.

Refuse chutes shall rest on substantial noncombustible foundations. The enclosing walls of such chutes shall consist of clay or shale brickwork not less than 8 inches thick or of reinforced concrete not less than 6 inches thick. Such chutes shall extend at least 4 feet above the roof and shall be covered by a metal skylight glazed with single thick plain glass.

Service openings for chutes shall be located, constructed and protected as required by the Building Code. Refuse chutes require automatic sprinkler systems for protection.

Other Types

Sec. 1805. Incinerators of types other than those regulated above shall be constructed and installed in accordance with the requirements of the Building Code, except that special large-capacity incinerators and refuse burners used in connection with sawmills and woodworking plants and other applications shall have special approval of the building official.

Chapter 19

MISCELLANEOUS HEAT-PRODUCING APPLIANCES

Ranges

Sec. 1901. (a) **Vertical Clearance above Cooking Top.** Domestic freestanding or built-in ranges shall have a vertical clearance above the cooking top of not less than 30 inches to unprotected combustible material. When the underside of such combustible material is protected with insulating millboard at least 1/4 inch thick covered with 0.021-inch-thick (No. 28 U.S. gage) or a metal ventilating hood, the distance shall be not less than 24 inches. For ducts serving domestic range hoods, see Section 1104.

(b) **Horizontal Clearance of Built-in Top Cooking Units.** The minimum horizontal distance from the center of the burner heads of a top (or surface) cooking unit to adjacent vertical combustible surfaces extending immediately above the counter top shall be at least the distance specified by the permanent marking on the unit.

Open-top Broiler Units

Sec. 1902. Listed open-top broiler units and hoods shall be installed in accordance with their listing and the manufacturer's installation instructions.

An exhaust duct and fan having a minimum capacity of 100 cfm per square foot of hood intake area shall be installed for a barbecue unit and, when the duct penetrates a ceiling or a floor, it shall be enclosed in a fire-resistive shaft covered on one side as required for a one-hour fire-resistive construction with no combustible material used inside the fire protection. The shaft shall be separated from the duct by a minimum 1-inch air space vented to the outside air, and the duct shall terminate not less than 18 inches above the roof surface. A minimum clearance of 24 inches shall be maintained between the cooking top and the combustible material and the hood shall be as wide as the open-top broiler and be centered over the unit.

Clothes Dryers

Sec. 1903. (a) **Moisture Exhaust Ducts.** Moisture exhaust ducts shall terminate on the outside of the building and shall be equipped with a back-draft damper. Screens shall not be installed at the duct termination. Ducts for exhausting clothes dryers shall not be connected or installed with sheet metal screws or other fasteners which will obstruct the flow. Clothes-dryer moisture-exhaust ducts shall not be connected to a gas vent connector, gas vent or chimney. Clothes dryer moisture exhaust ducts shall not extend into or through ducts or plenums.

(b) **Length Limitation.** Unless otherwise permitted or required by the dryer manufacturer's installation instructions and approved by the building official, domestic dryer moisture exhaust ducts shall not exceed a total combined horizontal and vertical length of 14 feet, including two 90-degree elbows. Two feet shall be deducted for each 90-degree elbow in excess of two.

(c) **Domestic Clothes Dryers.** When a compartment or space for a domestic clothes dryer is provided, a minimum 4-inch-diameter moisture exhaust duct of approved material shall be installed in accordance with this section and Section 1104.

(d) **Commercial Clothes Dryers.** The installation of commercial clothes dryer exhaust ducts shall comply with the appliance manufacturer's installation instructions.

Direct Gas-fired Makeup Air Heaters and Industrial Air Heaters

Sec. 1904 (a) **General.** Direct gas-fired makeup air heaters may be installed in commercial and industrial occupancies for heating incoming outside air for the purpose of replacing air exhausted from the space. Direct gas-fired industrial air heaters may be installed in commercial and industrial occupancies to offset building heat loss. Such equipment may be used to provide fresh air ventilation. Such equipment shall not supply an occupancy containing sleeping quarters.

(b) **Relief Openings.** The design of the installation shall include adequate provision to permit the equipment to operate at rated capacity by taking into account the structure's designed infiltration rate, providing properly designed relief openings, or an interlocked power exhaust system, or a combination of these methods.

Relief openings may be louvers or counterbalanced gravity dampers or, if motorized dampers, shall be interlocked so as not to permit equipment blower and main burner operation until they are proved in the open position.

(c) **Approval.** Each appliance shall be approved by the building official for safe use or comply with applicable nationally recognized standards as determined by an approved testing agency.

(d) **Air.** All air handled by direct gas-fired makeup air heaters, including combustion air, shall be brought in from outside.

Air to a direct gas-fired industrial air heater shall be taken from the building, ducted directly from outdoors, or a combination of both.

Unless the industrial air heater incorporates a means to supply ventilation air, outside ventilation air shall be provided to supply at least 4 cubic feet per minute per 1000 Btu/h of rated input. If a separate mechanical means is used, an interlock shall be provided so as not to permit main burner operation until the mechanical means is proved.

Recirculation of room air with an industrial air heater may be hazardous in the presence of flammable solids, liquids and gases; explosive materials (e.g., grain dust, coal dust, gun powder); and substances that may become toxic when exposed to heat (e.g., refrigerants, aerosols). Recirculation is not recommended in uninsulated buildings where the outside temperature falls below 32°F.

(e) **Plans.** The installer shall submit plans showing the proposed installation, indicating the location of the heater and such accessories as may be required to ensure the proper and safe performance of its function.

(f) **Filters.** All air passing through or over the burners shall be outside air and screened or filtered to prevent leaves, papers or other objects from being picked up from the outside, ignited and discharged into the heated space.

(g) **Clearance.** Such equipment shall be installed so as not to raise the temperature of surrounding combustible material more than 90°F. above ambient.

Small Ceramic Kilns

Sec. 1905. (a) **General.** The provisions of this section apply to kilns used for ceramics that have a maximum interior volume of 20 cubic feet and are used for hobby or noncommercial purposes.

(b) **Installation.** Kilns shall be installed in accordance with the manufacturer's instructions and the provisions of this code.

(c) **Fuel-gas Controls.** Fuel-gas controls shall comply with Sections 503 and 506. Standing pilots shall not be used with gas-fired kilns.

(d) **Electrical Equipment.** All electrical equipment used as part of, or in connection with, the installations of a kiln shall comply with the requirements set forth in the Electrical Code.

(e) **Installations inside Buildings.** In addition to other requirements specified in this section, interior installation shall meet the following requirements:

1. **Kiln clearances.** The sides and tops of kilns shall be located a minimum of 18 inches from any noncombustible wall surface and 3 feet from any combustible wall surface. Kilns shall be installed on noncombustible flooring consisting of at least 2 inches of solid masonry or concrete extending at least 12 inches beyond the base or supporting members of the kiln.

> **EXCEPTION:** These clearances may be reduced, provided the kiln is installed in accordance with its listing or to acceptable conclusions of testing reports submitted to the building official.

In no case shall the clearance on the gas or electrical control side of a kiln be reduced to less than 30 inches.

2. **Hoods.** A canopy-type hood shall be installed directly above each kiln. The face opening area of the hood shall be equal to or greater than the top horizontal surface area of the kiln. The hood shall be constructed of not less than 0.024-inch (No. 24 U.S. gage) galvanized steel or equivalent and be supported at a height of between 12 inches and 30 inches above the kiln by noncombustible supports.

> **EXCEPTION:** Electric kilns installed with listed exhaust blowers may be used when marked as being suitable for the kiln and installed in accordance with manufacturer's instructions.

3. **Gravity ventilation ducts.** Each hood shall be connected to a gravity ventilation duct extending in a vertical direction to outside the building. This duct shall be of the same construction as the hood and shall have a minimum cross-sectional area of not less than one fifteenth of the face opening area of the hood. The duct shall terminate a minimum of 12 inches above any portion of a building within 4 feet and terminate no less than 4 feet from any openable windows or other openings into the building or adjacent property line. The duct opening to the outside shall be shielded, without reduction of duct area, to prevent entrance of rain into the duct. The duct shall be supported at each section by noncombustible supports.

4. **Makeup air.** Provisions shall be made for air to enter the room in which a kiln is installed at a rate at least equal to the air being removed through the kiln hood.

5. **Hood and duct clearances.** Every hood and duct serving a fuel-burning kiln shall have a clearance from combustible construction of at least 18 inches. This clearance may be reduced in accordance with Table No. 5-B.

(f) **Exterior Installations.** Kilns shall be installed with minimum clearances as specified in Subsection (e) 1 of this section. Wherever a kiln is located under a roofed area and is partially enclosed by more than two vertical wall surfaces, a hood and gravity ventilation duct shall be installed to comply with Subsections (e) 2, (e) 3 and (e) 5 of this section.

Chapter 20

COMMERCIAL HOODS AND KITCHEN VENTILATION

Definitions

Sec. 2001. For the purpose of this chapter the following definitions shall apply:

COMMERCIAL FOOD HEAT-PROCESSING EQUIPMENT is equipment used in a food establishment for heat-processing food or utensils and which produces grease vapors, steam, fumes, smoke or odors which are required to be removed through a local exhaust ventilation system.

COMPENSATING HOOD is a hood that has an outside air supply with air delivered below or within the hood. When makeup air is diffused directly into the exhaust within the hood cavity, it becomes a short-circuit hood.

GREASE EXTRACTOR is a device designed to remove a large percentage of grease and other contaminants from the air before it enters the duct system. A listed grease extractor is one complying with the standard identified in Appendix C, Reference Standards.

GREASE FILTER is a device used to capture by entrapment, impingement, adhesion or similar means, grease and similar contaminants before they enter a duct system.

HOOD is an air-intake device connected to a mechanical exhaust system for collecting and removing grease, vapors, fumes, smoke, steam, heat or odors from commercial food heat-processing equipment.

Type I Hood is a kitchen hood for collecting and removing grease and smoke.

Type II Hood is a general kitchen hood for collecting and removing steam, vapor, heat or odors.

Kitchen Ventilation Systems

Sec. 2002. (a) **Materials.** 1. **Grease ducts.** Grease ducts and plenums serving a Type I hood shall be constructed of at least 0.055-inch-thick (No. 16 manufacturer's standard gage) steel or stainless at least 0.044 inch in thickness.

Exhaust fan housings serving a Type I hood shall be constructed of steel.

> **EXCEPTION:** Fans listed as "Power Roof Ventilators for Restaurant Cooking Appliances."

Joints and seams shall be made with a continuous liquid-tight weld or braze made on the external surface of the duct system. A vibration isolation connector may be used, provided it consists of noncombustible packing in a metal sleeve joint of approved design.

Duct bracing and supports shall be of noncombustible material securely attached to the structure and designed to carry gravity and lateral loads within the stress limitations of the Building Code. Bolts, screws, rivets and other mechanical fasteners shall not penetrate duct walls.

2. **Ducts, nongrease.** Ducts and plenums serving Type II hoods shall be constructed of rigid metallic materials as set forth in Chapter 10. Duct bracing and

supports shall comply with Chapter 10. Ducts subject to positive pressure shall be adequately sealed.

3. **Corrosion protection.** Ducts exposed to the outside atmosphere or subject to a corrosive environment shall be protected against corrosion. Galvanization of metal parts, protection with noncorrosive paints and waterproof insulation are considered acceptable methods of protection.

(b) **Prevention of Grease Accumulation.** Duct systems serving a Type I hood shall be so constructed and installed that grease cannot become pocketed in any portion thereof, and the system shall slope not less than 1/4 inch per lineal foot toward the hood or toward an approved grease reservoir. Where horizontal ducts exceed 75 feet in length the slope shall be not less than 1 inch per lineal foot. When a centrifugal fan is used it shall be positioned so the discharge outlet is either vertical or bottom horizontal with the air so diverted that there will be no impingement on the roof, other equipment or parts of the structure. A vertical discharge fan shall be manufactured with an approved drain outlet at the bottom of the housing to permit drainage of grease to an approved collection device.

When a centrifugal fan with bottom horizontal discharge is located outside the building, a duct or duct fitting that diverts the discharge from the grease exhaust duct system in an upward direction may be connected to the fan outlet, provided the following conditions are met:

1. The duct or duct fitting shall be constructed of metal as set forth in Tables Nos. 10-A and 10-B or U.M.C. Standard No. 10-2.
2. The maximum total developed length of the duct or duct fitting measured along the center line shall not exceed three times the vertical dimension of the fan outlet.
3. The duct or duct fitting shall be provided with openings at the lowest point to permit drainage of grease to an approved collection device.

(c) **Cleanouts and Other Openings.** Grease duct systems shall not have openings therein other than those required for proper operation and maintenance of the system. Any portion of such system having sections inaccessible from the duct entry or discharge shall be provided with adequate cleanout openings. Cleanout openings shall be equipped with tight-fitting doors constructed of steel having a thickness not less than that required for the duct. Doors shall be equipped with a substantial method of latching, sufficient to hold the door tightly closed. Doors shall be so designed that they can be opened without the use of a tool.

(d) **Duct Enclosure.** A grease duct serving a Type I hood which penetrates a ceiling, wall or floor shall be enclosed in a duct enclosure from the point of penetration. A duct may only penetrate exterior walls at locations where unprotected openings are permitted by the Building Code. Duct enclosures shall be constructed as the Building Code requires shaft enclosures to be constructed. Duct enclosures shall be of at least one-hour fire-resistive construction in all buildings and shall be of two-hour fire-resistive construction in Types I and II fire-resistive buildings. The duct enclosure shall be sealed around the duct at the point of penetration and vented to the exterior through weather-protected openings. The enclosure shall be separated from the duct by at least 3 and not more than 12 inches and shall serve a single grease exhaust duct system.

(e) **Fire-resistive Access Opening.** When cleanout openings are located in ducts within a fire-resistive shaft or enclosure, access openings shall be provided in the shaft or enclosure at each cleanout point. These access openings shall be equipped with tight-fitting sliding or hinged doors which are equal in fire-resistive protection to that of the shaft or enclosure.

(f) **Air Velocity.** Grease duct systems serving a Type I hood shall be designed and installed in a manner to provide an air velocity within the duct system of not less than 1500 feet per minute and not to exceed 2500 feet per minute.

(g) **Separation of Grease Duct System.** A separate grease duct system shall be provided for each Type I hood, except that a single duct system may serve more than one hood located in the same story of the building, provided that all hoods served by the system shall be located in the same room or adjoining rooms; portions of the interconnecting ducts shall not pass through any construction which would require the opening to be fire protected as specified in the Building Code.

(h) **Clearances.** Exposed grease duct systems serving a Type I hood shall have a clearance from unprotected combustible construction of at least 18 inches. This clearance may be reduced to not less than 3 inches, provided the combustible construction is protected with material required for one-hour fire-resistive construction.

(i) **Exhaust Outlets.** Exhaust outlets for grease ducts serving commercial food heat-processing equipment shall extend through the roof unless otherwise approved by the building official. Such extension shall be at least 2 feet above the roof surface, at least 10 feet from parts of the same or contiguous buildings, adjacent property line or air intake opening into any building, and shall be located at least 10 feet above the adjoining grade level.

> **EXCEPTIONS:** 1. Exhaust outlets for grease ducts serving commercial food heat-processing equipment may terminate not less than 5 feet from an adjacent building, adjacent property line or air intake opening into a building if the air from the exhaust outlet is discharged away from such locations.
>
> 2. Upon approval of the building official, the exhaust from any hood serving commercial food heat-processing equipment may terminate in a properly engineered air recovery system for recirculation to the room in which the hood is located.

(j) **Fuel-burning Appliances.** When vented fuel-burning appliances are located in the same room or space as the hood, the vent shall be arranged to prevent the hood system from interfering with normal operation of the appliance vent.

Hood

Sec. 2003. (a) **Where Required.** Hoods shall be installed at or above all commercial-type deep fat fryers, broilers, fry grills, steam-jacketed kettles, hot-top ranges, ovens, barbecues, rotisseries, dishwashing machines and similar equipment which produce comparable amounts of steam, smoke, grease or heat in a food-processing establishment. For the purpose of this section a food-processing establishment shall include any building or portion thereof used for the processing of food but shall not include a dwelling unit.

(b) **Materials and Installation.** Types I and II hoods shall be constructed of galvanized steel, stainless steel, copper or other material approved by building official for the use intended.

Type I hoods constructed of galvanized steel shall be at least 0.030 inch (No. 22 gage) steel.

Type II hoods shall be constructed of at least 0.024-inch (No. 24 gage) steel.

Hoods constructed of copper shall be of copper sheets weighing at least 24 ounces per square foot. Hoods constructed of stainless steel shall have a minimum thickness of 0.030 inch.

Hoods shall be secured in place by noncombustible supports.

Joints and seams shall be substantially tight. Solder shall not be used except for sealing a joint or seam.

(c) **Cleaning and Grease Gutters.** A hood shall be designed to provide for thorough cleaning of the entire hood when installed. When grease gutters are provided, they shall drain to a collecting receptacle, fabricated, designed and installed to be accessible for cleaning.

(d) **Clearances for Type I Hood.** A Type I hood shall be installed with clearance from combustible construction of at least 18 inches. This clearance may be reduced to 3 inches, provided the combustible material is protected with materials as specified for one-hour fire-resistive construction on the hood side. Hoods less than 12 inches from the ceiling or wall shall be flashed solidly with materials of the thickness specified in Section 2003 (b) or materials conforming to one-hour fire-resistive construction.

Type I hoods or portions thereof penetrating a ceiling, wall or furred space shall comply with all the requirements of Section 2002 (d).

(e) **Grease Filters.** Type I hoods shall be equipped with approved grease filters or grease extractors designed for the specific purpose. Grease collecting equipment shall be accessible for cleaning. The lowest edge of a grease filter located above the cooking surface shall be at least the height set forth in Table No. 20-A.

Filters and grease extractors shall be of such size, type and arrangement as will permit the required quantity of air to pass through such units at rates not exceeding those for which the filter or unit was designed or approved. Filter units shall be installed in frames or holders with handles by which they may be readily removed without the use of tools, unless designed and installed to be cleaned in place and the system is equipped for such cleaning in place. They shall be sized and made removable so they may be passed through a dishwashing machine or cleaned in a pot sink and so arranged in place or provided with drip intercepting devices as to avoid grease or other condensate from dripping into food or on food preparation surfaces.

Filters shall be installed at an angle greater than 45 degrees from the horizontal and shall be equipped with a drip tray beneath the lower edge of the filters.

(f) **Canopy Size and Location.** For canopy-type commercial cooking hoods the inside edge thereof shall overhang or extend a horizontal distance of not less than 6 inches beyond the edge of the cooking surface on all open sides, and the vertical distance between the lip of the hood and the cooking surface shall not exceed 4 feet.

> **EXCEPTION:** Listed grease extractors are to be installed in accordance with the terms of their listing and manufacturer's installation instructions.

(g) **Capacity of Hoods.** Canopy-type commercial cooking hoods shall exhaust through the hood a minimum quantity of air determined by application of the following formulas:

WHERE:

A = the horizontal surface area of the hood, in square feet.

P = that part of the perimeter of the hood that is open, in feet.

D = distance in feet between the lower lip of the hood and the cooking surface.

Q = quantity of air, in cubic feet per minute.

When cooking equipment is installed back to back and is covered by a common island-type hood, the airflow required may be calculated using the formula for three sides exposed. When all appliances are electric, the airflow required may be reduced to 80 percent of the formula value. Type II hood airflow requirements shall be in accordance with the requirements for low-temperature appliance hoods.

1. Type I hoods for use over charcoal and other solid-fuel charbroilers shall be provided with separate exhaust systems. Undefined cooking equipment other than charcoal and solid-fuel charbroilers may be installed under a common hood. The minimum airflow for charcoal-, solid-fuel and grease-burning charbroilers and undefined equipment shall be:

Number of Exposed Sides	**Formula**
4 (island or central hood)	$Q = 300A$
3 or less	$Q = 200A$
Alternate formula	$Q = 100PD$

2. Type I hoods when the cooking equipment includes high-temperature appliances such as deep-fat fryers:

Number of Exposed Sides	**Formula**
4 (island or central hood)	$Q = 150A$
3 or less	$Q = 100A$
Alternate formula	$Q = 100PD$

3. Type I hoods where the cooking equipment includes medium-temperature appliances such as rotisseries, grills and ranges.

Number of Exposed Sides	**Formula**
4 (island or central hood)	$Q = 100A$
3 or less	$Q = 75A$
Alternate formula	$Q = 50PD$

4. Type I hoods where the cooking equipment includes low-temperature appliances such as medium-to-low-temperature ranges, roasters, roasting ovens, pastry ovens and equipment approved for use under a Type II hood, such as pizza ovens.

Number of Exposed Sides	Formula
4 (island or central hood)	$Q = 75A$
3 or less	$Q = 50A$
Alternate formula	$Q = 50PD$

EXCEPTION: Listed grease extractors are to be installed in accordance with the terms of their listing and the manufacturer's installation instructions.

(h) **Capacity for Noncanopy Hoods.** In addition to all other requirements for hoods specified in this section, the volume of air exhausting through a noncanopy-type hood to the duct system shall be not less than 300 cubic feet per minute per lineal foot of cooking equipment. Listed grease extractors, filters and collector hoods shall be sized and installed in accordance with the terms of their listing and the manufacturer's installation instructions.

(i) **Makeup Air.** Each room provided with an exhaust system shall have air supplied to the room equal to the amount of air to be exhausted. Makeup diffusers shall be located to prevent a short-circuiting of air furnished to the exhaust system. Windows and doors shall not be used for the purpose of providing makeup air. The exhaust and makeup air systems shall be connected by an electrical interlocking switch. Compensating hoods shall meet the airflow requirements specified in Sections 2003 (g) 2 through 4. Compensating hoods shall extract at least 20 percent of their required exhaust airflow from the kitchen area.

(j) **Exhaust Outlet.** An exhaust outlet within the hood shall be so located as to optimize the capture of particulate matter. Each outlet shall serve not more than a 12-foot section of hood.

EXCEPTION: Listed grease extractors are to be installed in accordance with terms of their listing and the manufacturer's installation instructions.

(k) **Performance Test.** Upon completion and before final approval of the installation of a ventilation system serving commercial food heat-processing equipment, a performance test may be required to verify the rate of airflow and proper operation as specified in this chapter. The permitee shall furnish the necessary test equipment and devices required to perform the tests.

Motors, Fans and Safety Devices

Sec. 2004. (a) **General.** Motors and fans shall be of sufficient capacity to provide the required air movement as specified in this chapter. Electrical equipment shall be approved for the class of use as provided in the Electrical Code. Motors and fans shall be accessible for servicing or maintenance. Motors shall not be installed within ducts or under hoods.

(b) **Fire-extinguishing Equipment for Protection of Kitchen Grease Hoods and Ducts.** 1. **Where Required.** Approved fire-extinguishing systems shall be provided for the protection of commercial food heat-processing equipment.

EXCEPTION: The requirement for protection does not include steam kettles and steam tables or equipment which as used does not create grease-laden vapors.

2. **Extent of Protection.** The fire-extinguishing system used to protect ventilating hoods and ducts and cooking appliances shall be installed to include cooking surfaces, deep-fat fryers, griddles, upright broilers, charbroilers, grease-burning charbroilers, range tops and grills. Protection shall also be provided for the enclosed plenum space within the hood above filters and in exhaust ducts serving the hood.

EXCEPTION: That portion of the fire-extinguishing system required for protection of the plenum space within the hood beyond the filter and within the exhaust duct serving the hood may be omitted when approved listed grease extractors are installed.

3. **Type of System.** The system used for protection of commercial cooking equipment shall be either a system listed for application with such equipment or an automatic fixed pipe system that is specifically designed for such application. Listed systems shall be installed in accordance with their listing. Other systems shall be of an approved design and shall be of one of the following types:

A. Automatic sprinkler system.

B. Dry-chemical extinguishing system.

C. Carbon dioxide extinguishing system.

D. Wet chemical extinguishing system.

4. **Detailed Requirements.** A. When carbon dioxide systems are used, there shall be a nozzle at the top of the ventilating duct. Additional nozzles symmetrically arranged to give equal distribution shall be installed within vertical ducts exceeding 20 feet and horizontal ducts exceeding 50 feet. In carbon dioxide systems, dampers shall be arranged to operate automatically in the event that the extinguishing system operates. When the damper is installed at the top of the duct, the top nozzle shall be immediately below the damper. The quantity of carbon dioxide in the system shall be sufficient to protect all hazards venting a common duct simultaneously.

B. All fire-extinguishing systems shall be interconnected to the fuel or current supply so that the fuel or current is automatically shut off to all equipment under the hood when the system is actuated.

C. Shutoffs, valves or switches shall be of the type that requires manual operation to reset. In addition, carbon dioxide systems shall be similarly interconnected to shut off the ventilation fan.

D. Commercial cooking equipment protected by automatic sprinkler systems shall be controlled by a separate readily accessible indicating-types control valve that is identified. Where sprinklers are used to protect fryers, each fryer or pair of fryers shall be protected with a sprinkler arranged to operate at not less than 30 psi.

E. A readily accessible manual activating device installed at an approved location shall be provided for dry chemical, carbon dioxide and wet chemical systems. The actuation device may be either mechanically or electrically operated. If electrical power is used, the system shall be connected to a standby power system and a visual means shall be provided to show that the extinguishing system is energized.

5. **Posting Operating Instructions.** Instructions for manually operating the fire-extinguishing system shall be posted at a conspicuous location within the kitchen.

(c) **Fire Dampers.** Fire dampers shall not be installed in duct systems unless they are listed for such use or are part of a listed grease extractor, fire-extinguishing system or an approved fan bypass.

TABLE NO. 20-A—MINIMUM DISTANCE BETWEEN THE LOWEST EDGE OF A GREASE FILTER AND THE COOKING SURFACE OR THE HEATING SURFACE

	DUCT SYSTEM AND HOOD WITH FIRE-EXTINGUISHING SYSTEM (In Feet)
No exposed flame grills, french fryers, etc.	2
Exposed flame and burners	2
Exposed charcoal and charbroil-type fires	3½

APPENDIX

APPENDIX A

UNIFORM MECHANICAL CODE STANDARD NO. 4-2 GALVANIZED SHEET METALS

Based on Tentative Specification A525-64T of the American Society for Testing and Materials

See Sections 409 and 1003, Uniform Mechanical Code

Scope

Sec. 4.201. This standard covers the coating requirements for sheets in coils and cut lengths, zinc coated (galvanized) by the hot dip method to a coating weight of not less than coating class 1.25 "commercial." This material is intended to be used for duct construction.

Base Metal Manufacture

Sec. 4.202. The base metal shall be of approved composition made by the open hearth, basic oxygen or electric furnace process.

Weight of Coating

Sec. 4.203. (a) **General.** The coating shall have a total weight, on both sides of a sheet, of not less than 0.90 ounce per square foot of sheet when determined by the triple-spot check limit and not less than 0.80 ounce per square foot of sheet when determined by the single-spot check limit. Material after leaving the producer's plant shall be subject to the single-spot test only.

(b) **Coating Test.** The minimum check limit by the triple-spot test shall consist of the average of determinations from the test sheet as provided in Section 4.205.

The check limit by the single-spot test shall be that one of the three specimens of the triple-spot test bearing the lightest coating, or the building official may select a single specimen from any part of a sheet or coil as provided by Section 4.206.

The testing method shall determine to the nearest 0.01 ounce per square foot if the weight of coating in grams on a square sample 2.254 inches on a side or a circular sample 2.543 inches in diameter is numerically equal to the weight of coating in ounces per square foot of sheet.

Bend Test

Sec. 4.204. The bend test specimen specified in Section 4.207 shall stand being bent at room temperature through 180 degrees in any direction without flaking of the coating on the outside surface of the bend only. Flaking of the coating within 1/4 inch of the edge of the test specimen shall be disregarded.

Specimens for Triple-spot Test

Sec. 4.205. (a) **Cut Length Sheets 144 Inches and Less.** For triple-spot tests, three specimens 2.250 ± .010 inches square or 2.540 ± .010 inches in diameter shall be cut from each test sheet, one being cut from the center and the others from diagonally opposite corners adjacent to and within the boundary formed by lines not less than 2 inches from the sides and 4 inches from the ends.

(b) **Cut Length Sheets in Coils 144 Inches and Less.** For the triple-spot test, the three specimens may be cut from either end of each test sheet, one being cut from the middle of the width of sheet and the others, one from each side, adjacent to but not closer than 2 inches from the side edge.

(c) **Cut Length Sheets and Coils Over 144 Inches.** For the triple-spot test, a sample piece approximately 1 foot in length by width as coated shall be taken. Three specimens of the size specified in Section 4.204 (a) shall be taken from the sample piece.

Specimens for Single-spot Test

Sec. 4.206. The building official may select specimens for the single-spot test to be taken from any part of the sheet or coil for material less than 2.25 inches. The test specimen length shall be chosen to give a specimen equal to 5.06 square inches.

Specimens for Base Metal Bend Test

Sec. 4.207. Bend test specimens shall be 2 to 4 inches in width and may be cut from any sheet or coil. The bend test specimen shall not be taken closer than 2 inches from the sides nor 4 inches from the ends.

Dimensional Requirements

Sec. 4.208. The dimensional properties shall be not less than shown in Table No. 4-2-A.

Defects

Sec. 4.209. Material which is damaged or which contains any injurious defect such as blisters, flux or uncoated spots shall not be used.

Rejection

Sec. 4.210. If the building official ascertains that the material fails to conform to the requirements of this standard he may reject the use of such material.

TABLE NO. 4-2-A—DIMENSIONAL REQUIREMENTS FOR GALVANIZED SHEET METAL

GALVANIZED SHEET GAGE NO.	OUNCES PER SQUARE FOOT	POUNDS PER SQUARE INCH	NOMINAL THICKNESS EQUIVALENT FOR GALVANIZED SHEET GAGE NO.
12	72.5	0.0314670	.1084
13	62.5	0.0271270	.0934
14	52.5	0.0227860	.0785
15	47.5	0.0206160	.0710
16	42.5	0.0184460	.0635
17	38.5	0.0167100	.0575
18	34.5	0.0149740	.0516
19	30.5	0.0132380	.0456
20	26.5	0.0115020	.0396
21	24.5	0.0106340	.0366
22	22.5	0.0097656	.0336
23	20.5	0.0088976	.0306
24	18.5	0.0080295	.0276
25	16.5	0.0071615	.0247
26	14.5	0.0062934	.0217
27	13.5	0.0058594	.0202
28	12.5	0.0054253	.0187
29	11.5	0.0049913	.0172
30	10.5	0.0045573	.0157

UNIFORM MECHANICAL CODE STANDARD NO. 10-1
FACTORY-MADE AIR DUCTS

Based on Standards No. 181 (September 1981) and No. 214 (1976) of Underwriters Laboratories Inc.

See Sections 1002, 1004 and 1005, Uniform Mechanical Code

Scope

Sec. 10.101. These requirements apply to materials for the fabrication of air-duct systems for installation in buildings, including preformed lengths of flexible or rigid ducts, and materials in the form of sheets or boards for field fabrication of lengths of rigid duct.

Classification

Sec. 10.102. For the purpose of this standard, materials shall be classified as follows:

Class 0—Air-duct materials having a surface-burning characteristic of zero.

Class 1—Air-duct materials having a flame-spread index of not over 25 without evidence of continued progressive combustion and a smoke-developed index of not over 50.

Class 2—Air-duct materials having a flame-spread index of not over 50 without evidence of continued progressive combustion and a smoke-developed index of not over 50 for the inside surface material and not over 100 for the outside.

Instructions

Sec. 10.103. Installation instructions shall be available from the manufacturer. Instructions shall be illustrated and shall include directions and information for attaining proper and safe installation of the product. (See Section 10.123.)

Performance

Sec. 10.104. Air-duct materials and joining materials shall be tested for performance under applicable tests set forth in Table No. 10-1-A.

Construction

Sec. 10.105. Materials for factory-made ducts shall be basically metal or mineral. Nonmetallic or organic materials may be used as binders, adhesives, sealants or finishes if the product otherwise conforms to these requirements. Unbonded asbestos fiber materials shall not be used.

Tests for Surface-burning Characteristics

Sec. 10.106. (a) **Required Performance of Materials.** Materials for ducts shall be tested for surface-burning characteristics and shall conform to the following requirements:

Class 0 air-duct materials shall have a surface-burning characteristic of zero (flame spread and smoke developed).

Class 1 air-duct materials shall have a flame-spread index of not more than 25 without evidence of continued progressive combustion and a smoke-developed index of not more than 50.

Class 2 air-duct materials shall have a flame-spread index of not more than 50 without evidence of continued progressive combustion and a smoke-developed index of not more than 50 for the inside surface material and not more than 100 for the outside surface material.

(b) **Method of Determining Tests for Surface-burning Characteristics.** Surface-burning characteristics tests shall be determined utilizing the method of test prescribed in U.B.C. Standard No. 42-1. The manufacturer shall furnish a qualitative analysis of materials used in the product including tapes, cements, finishes, etc. If the inside and outside surfaces of a duct are of different composition, tests shall be conducted exposing first one side and then the other in the test furnace, using different samples for each exposure. Fabrics, tapes and other joining materials, field-applied to or forming a part of a factory-made duct or part, are considered as components of the product and shall be in place during the test for surface-burning characteristics. If, however, the application of the fabric, tape or other joining material to the sample is likely to affect the various surface-burning characteristic ratings, samples shall be tested with and without longitudinal seams or joints and the highest classification ratings reported.

When necessary due to unusual characteristics of a composite duct that may affect the conduct of the test, the duct construction may be supported on $^1/_4$-inch-diameter steel rods spaced between 2 feet and 4 feet apart.

Flame-resistance Test

Sec. 10.107. (a) **Conditions of Acceptance.** Fabrics, tapes and other joining materials intended for exposure in the internal duct air stream shall exhibit the following properties:

1. The specimen shall not continue to flame more than two seconds after withdrawal of the test flame.
2. Portions or residues which break or drip from a test specimen shall not continue to flame after falling.
3. The vertical spread of flame and afterglow (smoldering combustion) on the specimen, shall not exceed the length of char indicated in the tabulation below:

LENGTH OF CHAR

Weight of Fabric or Tape—Oz./Yd.2	Max. Average Length of Char or Destroyed Material 10 Specimens (Inches)	Max. Length of Char or Destroyed Material Any Single Specimen (Inches)
over 10	3.5	4.5
over 6	4.5	5.5
6 or less	5.5	6.5

(b) **Selection and Conditioning of Specimens.** Samples of fabrics, films and tapes which are exposed to the internal air stream shall be supplied by the applicant and certified as representative of materials used in production or supplied with the duct. Materials shall be supplied full width despite the fact that in production they may subsequently be split, ripped or cut for application to the duct. The unit weight of each fabric, film or tape shall be determined by weighing the samples and computing the weight per square yard. Ten specimens 2-3/4 inches by 10 inches of each fabric, film or tape shall be cut from locations as widely separated and as symmetrically located as possible over the area of the fabric, film or tape sample. Five of the specimens shall be cut with the long dimension in the direction of the warp or the lengthwise direction of the roll; five shall be cut in the direction of the woof or direction of roll width.

Specimens shall be conditioned by suspending them in an oven having mechanical circulation of air, at a temperature of 140° to 145°F. for not less than one hour nor more than one and one half hours. After conditioning, specimens shall be maintained in a desiccator until tested.

(c) **Test Equipment.** Flame-resistance testing shall be conducted in a sheet steel enclosure 12 inches square in cross section and at least 30 inches high. The enclosure, open at top, bottom and one side, shall be provided with a door or sliding panel having an observation window. Provision shall be made for moving a gas burner used in igniting the specimen into test position after the door or sliding panel is closed. A rod attached to the base of the burner and extending through a slot near the bottom of one side of the enclosure will serve the purpose. The Bunsen burner having a 3/8-inch I.D. tube shall be supplied with gas having a heating value of 800 to 1000 Btu per cubic foot and adjusted to provide a luminous flame 1 1/2 inches long with the air supply completely shut off.

(d) **Test Procedure.** Test specimens shall be supported in a metal holder which clamps each long edge of the sample leaving the ends free and exposing a strip 2 inches wide and 10 inches long. The holder with sample is suspended vertically from a clamp in the test enclosure, with its lower end 3/4 inch above the tip of the Bunsen burner. The flame is applied near the lower end of the sample for 12 seconds and then withdrawn. Observations shall be recorded during and after the flame application to include duration of surface flaming and length of charred or destroyed material. The burner may be vertical or, if it is expected that portions of the material being tested may drip or fall on the burner so as to alter the test flame, the burner may be supported so that the barrel is at an angle of 25 degrees from the vertical.

(e) **Evaluation of Char.** The length of char is determined by inserting wire hooks, one from each side of the charred area, 1/4 inch from the bottom and outside edges of the specimen. A weight as specified below is to be attached to one hook and applied to the specimen without impact by slowly raising the other hook. The specimen tears through the charred area until the fabric is strong enough to carry the load. The length of char is the distance from the end of the specimen which was exposed to the flame to the end of the tear made by the hook lengthwise in the specimen.

TEARING WEIGHTS

Weight of Fabric Oz./Yd.2	Applied Weight—Pounds
2 to 6	0.25
more than 6 to 15	0.50
more than 15 to 23	0.75
over 23	1.00

When it is infeasible to measure the length of the char by tearing, because of the nature of the material, the extent of destruction may be taken as the measurement from the bottom of the sample to a horizontal line above which all material is sound and in apparently original condition except for possible smoke deposits.

Flame-penetration Test

Sec. 10.108. (a) **Retardation.** Materials for the fabrication of Class 0 and Class 1 air ducts shall retard the passage of flame for a period of at least 30 minutes and for Class 2 air ducts shall retard the passage of flame for at least 15 minutes when tested in accordance with the method described in this section.

(b) **Test Furnace.** Flame-penetration tests are to be conducted using a refractory-lined gas-fired combustion chamber open at the top. The sample to be tested is to be used to form the top of the chamber.

The furnace shall be equipped with a dual outlet gas burner composed of pipe fittings. The gas burner shall not have any means for premixing of gas and combustion air. The furnace is to be vented directly into the room space in which it is located by means of four vent openings. No dampers or regulators are to be employed in openings provided for inlet of combustion air or for venting. The furnace is to be lined with high-duty regular-type fireclay brick having a density of 125 to 135 pounds per cubic foot.

The furnace shown in Figure 10-1-1 is to be equipped with a gas burner to burn technical grade or purer methane (bottled) gas having a heating value of 1000 to 1050 Btu per cubic foot. A flanged union incorporating a thin plate orifice shall be installed in the burner piping sized to flow 53 cubic feet per hour (nominal) of natural gas at a pressure of 3-$^1/_2$-inch water column. The room in which the test furnace is to be located is to be large in relation to the furnace and ventilated to provide adequate air for combustion. Ventilation is to be accomplished without appreciable air movement in the vicinity of the furnace.

(c) **Sample.** Samples are to be prepared from previously untested materials. Samples of flexible ducts are to be cut from ducts having a minimum inside diameter of at least 12 inches. Rigid duct samples are to be prepared in 24-inch flat squares. Materials used in the construction of the sample ducts are to be identical to those used in regular finished production. The material surface which is considered to be the outside surface of the air duct is to be the surface exposed to the flame during the test. Test samples are to be mounted in a frame fabricated as shown in Figure No. 10-1-2. The steel plate is to be tightened against the upper frame so that the sample is held firmly in place throughout the test duration.

> **EXCEPTION:** If a duct at least 12 inches in diameter is not produced, then the largest diameter duct that is produced is to be used for the test.

The test sample is to be subjected during the test to a static load of 2 pounds-mass per square inch over a bearing surface on the sample of 1 by 4 inches, located at the geometric center and rotated to any position determined to be most critical for penetration on the upper surface of that part of the sample exposed to the flame.

(d) **Conduct of Test.** Prior to the beginning of a test series, the furnace is to be fired for a period of at least two hours, using a section of calcium silicate board (18 pounds per cubic foot) to form the top of the furnace combustion chamber. The input to the gas burner is to be adjusted by means of a pressure regulator ahead of the thin plate orifice to obtain a fuel input of 54,500 (± 500) Btu per hour. Minor adjustments are to be made during this and any subsequent preheating period to maintain this fuel input. For each succeeding test to be conducted immediately following a test, the calcium silicate board is to be replaced on the furnace and the furnace fired for at least one hour before beginning the next test. At the end of the preheating period, the calcium silicate is to be removed and the air-duct test sample immediately substituted in its place. The static load is to be placed on the sample three seconds after the test sample is in place. The gas input to the furnace is not to be disturbed during this changeover and any subsequent test period. The test is to be continued for a period of 30 minutes for Class 0 and Class 1 air-duct materials, and 15 minutes for Class 2 air-duct materials. The test period is to be measured from the time the static load is applied to the test sample.

(e) **Performance.** The sample shall withstand the flame-penetration test without collapse, evidence of perforation to an extent which would allow the direct passage of flame or gases, and without ignition occurring on the surface of the sample exterior to the combustion zone of the test furnace. The test series shall consist of a set of three samples. All samples in the set shall comply with the applicable flame-penetration test requirements as specified for Class 0, Class 1 or Class 2.

Burning Test

Sec. 10.109. (a) **General.** Ducts shall not continue to burn progressively, and exterior surfaces of the material shall not drop particles capable of igniting untreated surgical cotton when tested in accordance with this section.

(b) **Samples.** Six 3-foot-long representative samples without transverse joints of assembled duct sections shall be selected for test. If the material is of uniform grade and thickness for all sizes of ducts and of similar cross-sectional shape (rectangular or round), samples are to be selected from the largest and smallest sizes. If the ducts vary in shape or the material varies in grade and thickness with size, additional samples to be representative of the complete line shall be required for test. Consideration is to be given to selecting samples which will be the most vulnerable to burning under the conditions of test. Any adhesive or cement is to be allowed to cure for a period of at least 24 hours. Samples are not to have been exposed to relative humidity greater than 70 percent during the 24-hour period prior to the test.

(c) **Test Apparatus.** The apparatus to be employed consists of a Bunsen burner with a $^3/_8$-inch-diameter tube and means for controlling the primary air and gas input, a support for the burner, a stopwatch or other timing device, and a supply of untreated surgical cotton. Suitable apparatus for holding the test sample will be required, but will vary depending on the design and size of sample. The tests are to be conducted in a location free from drafts.

Two of each set of samples are to be supported with their axes horizontal, two samples are to be supported with their axes at 45 degrees from the horizontal, and two samples are to be supported with their axes vertical. The burner is to be ignited and adjusted to produce a flame 2 to 3 inches high. Attempts to ignite the material are to be made with the flame varied from blue to yellow.

(d) **Conduct of Test.** The test flame is to be applied at locations 3 inches from end of the test sample. This may necessitate orienting the burner at an angle when testing the vertical sample. The outside surface of three samples oriented in the three positions is to be exposed to the flame for one minute and then the flame is to be withdrawn. If flaming or glowing combustion of the sample ceases 60 seconds or less after removal of the test flame, the test flame is to be reapplied at the same place for one minute immediately after flaming or glowing combustion of the sample stops. The test flame is again to be withdrawn and the duration of flaming or glowing combustion of the sample noted. During the test of an individual sample, the original size and characteristic of the test flame is not to be changed.

If the samples oriented horizontally and 45 degrees from the horizontal drop particles during the test, these particles are to be allowed to fall onto a horizontal plane 1 foot below the nearest part of the test sample. The plane is to be covered with a layer of untreated surgical cotton except that portion of the area directly below the burner extending for a distance of 6 inches measured horizontally in all directions from a vertical axis through the tip of the burner flame.

Following exposure of the exterior surface of the first three samples, similar tests are also to be conducted on the remaining three samples of the set by applying flame to the inside surface. Depending on the size and orientation of the sample, it may be necessary to cut away part of the sample in order to apply the test flame. These samples are to be observed for flaming or glowing combustion only and surgical cotton is not to be placed beneath the samples during this test.

(e) **Performance.** To conform to the requirements for this test, the duration of flaming or glowing of any sample after withdrawal of the test flame is not to exceed 60 seconds, flaming or glowing is not to travel to the end of the sample farthest from the point of application of the test flame, and particles dropped from the exterior surface of the sample are not to ignite the surgical cotton.

Corrosion Requirements

Sec. 10.110. (a) **General.** Metals used in ducts shall be resistant to atmospheric corrosion and shall not be used in combinations such as to cause detrimental galvanic action which will adversely affect any of the system formed from such material. Metallic materials which are not inherently corrosion resistant such as sheet steel or steel wire shall be provided with a corrosion-resistant coating providing protection against atmospheric corrosion equivalent to that of galvanized steel having a coating of zinc of not less than 0.3 ounce per square foot of surface area. Materials which may have their protective coating damaged or the effectiveness reduced by the manufacturing process shall be tested after being subjected to such process.

(b) **Test for Zinc-coated Steel.** The amount of zinc coating shall be determined by the Standard Method of Test for Weight of Coating on Zinc-coated (Galvanized) Iron or Steel Articles, ANSI/ASTM A 90-69(1978). If flaking or cracking of the zinc coating at the outside radius of a bent or formed section visible at 25-power magnification, or if the coating is scored, the zinc coating is considered to be damaged and is unacceptable.

(c) **Tests for Coated Steel (Other Than Zinc-coated Steel).** The following tests shall be conducted on coated materials other than galvanized steel after the material has been formed for use in the finished product. The tests shall be conducted on samples of the coated material and on zinc-coated steel having the minimum coating of zinc specified in paragraph 10.110 (a), and continued until equivalency is demonstrated. Samples having organic coatings shall be tested in the as-received condition and also after having been exposed to temperature as encountered in the high-temperature phase of the temperature test, Subsection 10.112 (c).

(d) **Salt-spray Test.** The apparatus for salt-spray (fog) testing shall consist of a fog chamber, the inside of which measures 48 by 30 by 36 inches, salt-solution reservoir, a supply of conditioned compressed air, one dispersion tower constructed in accordance with Salt-spray Testing, ANSI/ASTM B 117-73(1979), for producing a salt fog, specimen supports, provision for heating the chamber, and necessary means of control. The dispersion tower for producing the salt fog shall be located in the center of the chamber and shall be supplied with humidified air at a pressure of 17 to 19 psig so that the salt solution is aspirated as a fine mist or fog into the interior of the chamber.

The salt solution shall consist of 20 percent by weight of common salt (sodium chloride) and distilled water, and the pH value of the collected solution shall be between 6.7 and 7.2 with a specific gravity of 1.126 to 1.157 at 95°F. The temperature of the chamber shall be maintained at 95° plus 2 or minus 3°F. throughout the test.

Drops of solution that accumulate on the ceiling or cover of the chamber shall not be permitted to drop on the specimens, and drops of solution that fall from the specimens shall not be recirculated but shall be removed by drains located at the bottom of the apparatus.

(e) **Industrial Atmosphere Test.** The test specimens shall be supported vertically in a closed chamber having opening for gas inlet and outlet. Sulfur dioxide and carbon dioxide shall be supplied to the test chamber from commercial cylinders containing these gases under pressure. An amount of sulfur dioxide equivalent to 1 percent of the volume of the test chamber and an equal volume of carbon dioxide shall be introduced into the chamber each working day. A small amount of water shall be maintained at the bottom of the chamber.

(f) **High-temperature and Humidity Test.** The test specimens shall be supported vertically in a closed chamber at a constant temperature of 104°F. and 100 percent relative humidity.

Mold Growth and Humidity Test

Sec. 10.111. Materials for ducts including any tapes, fabrics, cements or other materials to be used in assembly during installation shall be resistant to the effects of high humidity under ordinary atmospheric temperature conditions when tested in accordance with this section.

Three samples representing typical wall areas of the assembled duct are to be prepared. Each sample is to be approximately 4 inches square and is to include joining material, if such is employed in the installation of duct systems.

Mold mycelia and spores from bread are to be applied to the samples. The samples are to be placed in a closed vessel in which an atmosphere, saturated with water vapor, is maintained at room temperature and under dark conditions. The samples are to remain in such atmosphere until the extent of growth has been demonstrated or until the mold and spores have disintegrated, but not less than 60 days.

The samples are then examined visually for extent of mold growth and for indications of deterioration in wall structure, exterior casing, inner lining, tapes, fabrics, etc. The mold is not to have spread beyond the inoculated area, and no significant growth of mold is to be observed. Structural material is not to become deformed or delaminated; tapes, casing and lining are to remain securely in place, and joints are not to open up or show evidence of separation. As an alternate or referee method, the foregoing test may be conducted using chaetomium globosium instead of bread mold.

Temperature Test

Sec. 10.112. (a) **General.** Materials for ducts, including any tapes, fabrics, cements or other materials to be used in assembly during installation, shall be resistant to the effects of the temperatures to which they are exposed as provided in this section.

(b) **Low-temperature Test.** Three samples representing typical wall areas of the assembled product are to be prepared. Each sample is to be approximately 8 by 8 inches square and is to include joining material, if such is employed in the installation of duct systems. The samples are to be placed in a closed vessel in which an atmosphere saturated with water vapor is maintained at room temperature for a period of 48 hours. The samples are then to be removed and immediately placed in a refrigerated compartment and maintained at a temperature of 0°F. for a period of 24 hours. The samples are then to be examined visually for indictions of deterioration in wall structure, exterior casing or interior linings, tapes, fabrics, cements, etc. Structural material is not to become deformed or show delamination; tapes, casings and lining are to remain securely in place, and joints are not to open up or show evidence of separation.

(c) **High-temperature Test.** At least two representative samples are to be selected and prepared for this test. If the product is of uniform grade, thickness and cross section, such as square or round, the samples are to be selected from the smallest sizes. Square or round sections, varying in grade and thickness with size, may also require samples in other size ranges. Rectangular sections are to be selected on the basis of grade, thickness and size. In selecting samples of duct sections, shapes which will be most vulnerable to damage under the conditions of the puncture test are to be chosen.

Each sample is to be 3 feet long and is to be made up from two sections of duct providing for a joint between sections located 2 feet from one end. At least one end of each sample is to be attached to a metal collar in accordance with the manufacturer's instructions.

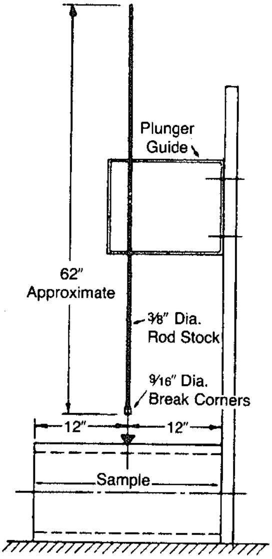
The exterior and interior surfaces of samples of duct sections are to be simultaneously exposed to air maintained at not less than 125°F. on the exterior and not less than 265°F. on the interior. Any practical arrangement using samples of duct sections may be employed. The test arrangement is to provide means for maintaining air at the specified test temperatures in moving contact with the two surfaces of the test samples.

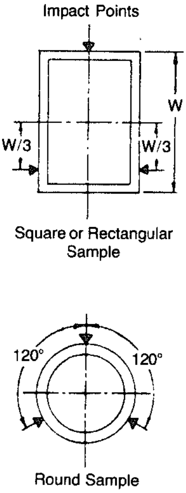
The conditions of test are to be maintained for a period of 60 days. The samples are then to be examined visually for indications of deterioration in wall structure, exterior casings or interior linings, tapes, fabrics, cements, etc. Structural material is not to become deformed or show delamination; tapes, casings and lining are to remain securely in place, and joints are not to open up or show evidence of separation.

Puncture Test

Sec. 10.113. (a) **General.** An air duct shall resist puncture when tested in accordance with the requirements of this section.

(b) **Test Requirements.** Test apparatus providing for a free fall of a plunger onto the surface of the sample is to be used for this test. The plunger is to consist of 3/8-inch-diameter steel rod having a steel head 9/16-inch-diameter attached to the impact end. The length of the plunger assembly is to be sufficient to provide a 2-pound weight. The surfaces of the rod and head are to be smooth. The impact end of the rod is to be flat with a chamfered edge. Guides arranged to allow for a practically frictionless fall of the plunger are to be provided. A means for measuring the height of the fall is to be provided.





(c) **Samples.** The 2-foot sections of the air-duct samples previously subjected to the temperature test requirements in Section 10.112 (b) and (c), as well as identical samples prepared from untested product, are to be subjected to this test. The samples are to be provided with a firm support below and throughout their length and width. At least three areas of each sample are to receive the impact of the plunger at impact points indicated by the accompanying diagram.

(d) **Acceptance.** To conform to the requirements for resistance to puncture, the samples are to prevent the complete penetration of the plunger head falling through a distance of 20 inches as measured to the top surface of the sample.

Static Load Test

Sec. 10.114. (a) **General.** Sections of rigid air ducts assembled in accordance with the manufacturer's instructions shall not sag, permanently deform or be damaged as the result of static loading as provided for in this section.

(b) **Selecting Samples.** Representative samples are to be selected or prepared. If sections are of uniform grade, thickness and cross section, such as square or round, the samples are to be selected from the largest and the smallest sizes. Square or round sections, varying in grade and thickness with size, may also require samples in the intermediate size range. Rectangular sections are to be selected on the basis of grade, thickness and size, as well as the largest ratio of width to depth produced by the manufacturer. Consideration is to be given to selecting sample shapes which will be the most vulnerable to damage under the conditions of test.

(c) **Preparing Samples.** Samples for test are to be at least 2 feet longer than the maximum span distance between supports recommended in the manufacturer's instructions for the various sizes, grades and shapes, but not less than 8 feet long. Samples are to be made up to provide for a circumferential joint at the center of the sample unless supports are recommended to be located at each joint, in which case manufacturer's instructions are to be followed. If joints are reinforced to the extent that the section may be more resistant to load than a section without a joint, additional samples of sections without the joint are to be tested; except that if the longest section obtainable from the material under test is less than 8 feet, additional pieces may be joined thereto so that the longest section is midway between the supports. Any adhesives or cements are to be allowed to cure for a period of at least 24 hours. Samples are not to have been exposed to relative humidity greater than 70 percent during the 24-hour period prior to the test.

(d) **Supporting Samples.** The samples are to be placed horizontally on hangers located at the interval recommended in the manufacturer's instructions, except that hangers are to be located on centers not less than 16 inches. Rectangular samples are to be placed with the major axis in the horizontal plane. Special bearing blocks, or other reinforcing means, are to be used if supplied as factory-made parts. Steel pipe strap hanger material 1 inch wide is to be used to support the test sample, locating each hanger not less than 1 foot from the end of the sample. If support at intervals less than 6 feet is recommended, additional support straps as needed to support the 8-foot test sample at the recommended interval are to be provided.

(e) **Deflection.** With a sample supported as described above, means are to be provided for measuring to the nearest $^1/_{16}$ inch the vertical deflection at the center of the horizontal length. This measurement is to be that taken between the bottom of the sample at the center and the floor or other datum point below the sample. Any deflection due to stretching of the hanger is to be deducted.

A static load is to be applied at the longitudinal center of the sample by suspending two 5-pound weights on 1-inch-wide pipe strap material. The maximum vertical deflection measured at the bottom of the test sample, expressed as a percentage of the distance between supports, is not to exceed:

1. 0.7 percent at the end of five minutes.
2. 0.8 percent at the end of one hour.
3. 1.0 percent at the end of 24 hours.
4. 0.8 percent at the end of five minutes after removal of the load.

(f) **Performance.** Following the test, the inner and outer surfaces of the sample shall not be ruptured, broken, torn, ripped or separated; joints and seams shall remain intact and not be fractured, and there shall be no evidence of other damage to the sample which would cause it to be unusable.

(g) **Flexible Air Ducts.** Flexible air ducts that incorporate vapor barriers supported by grommets or other mechanical means of field support shall not be damaged when subjected to a load of two and one-half times the total weight of an 8-foot-long sample of the duct. Previously untested samples are to be used for this test. This test is to be conducted only on samples of duct sizes that result in the maximum weight intended to be supported by any given grommet size or spacing. Samples are to be supported in accordance with the methods and spacings recommended by the manufacturer. The load is to be uniformly applied to the duct so that it is supported by the support system. If possible, the load is to be applied by laying rods on the inside of the duct. After supporting the load for 24 hours, the sample shall show no evidence of rupture, breakage, tearing, ripping, collapse, separation or otherwise be unusable.

Impact Test

Sec. 10.115. (a) **General.** Sections of air ducts assembled in accordance with the manufacturer's instructions shall resist damage as a result of the impact when tested in accordance with this section.

(b) **Selecting Samples.** Representative samples are to be selected or prepared as provided for the static load test in Section 10.114(b).

(c) **Preparing Samples.** Samples 8 feet long are to be made up to provide for a circumferential joint at the center of the sample. In making up a sample of flexible duct, the material is to be extended to its normal length. If the joint is reinforced to the extent that the section may be less vulnerable to the test than a section without the joint, additional samples of sections without the joint are to be tested; except that if the longest section obtainable from the material under test is less than 8 feet, additional pieces may be joined thereto to provide a sample 8 feet long, in which case the longest piece is to be in the middle of the test section. Any adhesives or cements are to be allowed to cure for a period of at least 24 hours. Samples are not to have been exposed to relative humidity greater than 70 percent during the 24-hour period prior to the test. The sample is to be placed upon a firm, flat surface, such as a concrete floor, for the test.

(d) **Test Apparatus.** The impact is to be that of a canvas bag containing sand and weighing 20 pounds. The bag is to be formed of 8-ounce duck, drawn tightly around the sand and tied with a cord. The bag is to be raised above the top of the duct and allowed to fall 10 inches so as to strike the top of the duct on its longitudinal axis.

An impact is to be made at the longitudinal center of the test sample and another at a point halfway between the center and one end of the test sample.

(e) **Performance.** Following the test, the inner and outer surface of the sample shall not be ruptured, broken, torn, ripped, collapsed or separated; joints and seams shall remain intact and not be fractured; there shall be no evidence of other damage to the sample which would cause it to be unusable. Collapse is defined as any reduction in external and/or internal cross-sectional area exceeding 20 percent.

Erosion Test

Sec. 10.116. (a) **Test Samples.** One or more of the samples of duct sections previously subjected to the impact test are to be subjected to the test for erosion. The sample or samples selected are to be arranged in an L-shaped assembly. When sections of duct are to be tested, the leg of the assembly connected to the fan outlet is to be the section which has been subjected to the impact test and the down leg is to be of similar untested material having a length of not less than six times the major inside dimension of the duct section. For rigid ducts, the 90-degree bend is to be made with an elbow as normally employed for installations. Flexible ducts are to be bent at a radius equivalent to the inside diameter of the duct to form the 90-degree bend. The entire assembly is to be similar in cross sections.

Connection to the outlet of the fan is to be by means of a transformation piece of any suitable material to provide for uniform air entry to the test sample. The fan is to have sufficient capacity to provide the test velocity which shall be two and one-half times the maximum velocity recommended by the manufacturer, but not less than 2500 feet per minute of air at room temperature.

(b) **Procedure.** The air velocity for purposes of the test is to be measured by a Pitot tube, or direct-reading velometer, positioned in the center of the outlet end of the sample. Room air handled by the fan and ranging in temperature between 60° and 100°F. may be employed.

The inlet of the air fan used for the test is to be covered with a double layer of cheesecloth (14 to 15 square yards per pound and known to the trade as "count of 32 by 28"). A damper, if employed for regulating velocity in the duct system, is to be located between the screen and the fan or between the fan and the inlet to the test sample. A collecting screen consisting of a double layer of cheesecloth, as specified in this paragraph, stretched taut on a frame sized to provide for an area not less than five times the inside cross-sectional area of the test sample, is to be located 1 foot from the outlet end of the test sample.

Samples are not to have been exposed to relative humidities greater than 70 percent during the 24-hour period prior to the test. Air is to be passed through the sample at approximate test velocity with the collecting screen removed for a period of at least one hour but not more than 24 hours. The collecting screen is then to be placed in position.

(c) **Performance.** The test is then to proceed at test velocity and continue for a period of four hours. The collecting screen is to be examined for macroscopic particles at the end of each hour during the test period by taping the screen with the adhesive side of transparent tape in order to remove and record any eroded particles. At the end of the test period, there is to be no evidence of continued erosion, and interior surfaces of the sample are not to show evidence of cracking, flaking, peeling or delamination. For the purpose of this requirement, continued erosion is considered to be either a constant or an increasing rate of erosion.

Pressure Test

Sec. 10.117. (a) **General.** Duct sections with joints, assembled in accordance with the manufacturer's instructions, shall withstand without rupture an internal air pressure of two and one-half times the manufacturer's rated positive pressure, but not less than 1 1/4-inch water column.

(b) **Test Samples.** Samples of duct previously untested are to be used for the test. Samples 8 feet long are to be selected and prepared in accordance with Subsections 10.114 (b) and (c). Each end of the sample is to be sealed airtight by any means consistent with the use of the material under test. In the case of a flexible air duct, to permit the air duct to be fully extended to its maximum length, the air duct is to be pressurized to 0.25-inch water column. Each end of the flexible air duct is to be attached to a stationary fixture. A pressure tap consisting of pipe or tubing is to be sealed into one end of the test sample and connected to a water manometer which may be read directly to 0.05-inch water column. The manometer is to be checked for zero reading at the beginning and at the end of each test.

An air-supply tap consisting of pipe or tubing is to be sealed into the same or the other end of the sample and connected to a source of air pressure capable of maintaining the specified air pressure in the sample.

(c) **Performance.** The air pressure in the test sample is to be maintained at the designated test pressure for a period of one hour. The sample is not to rupture, as evidenced by breaks, tears, rips or other openings greater than 1/8 inch in length; any joining material is to remain intact to the extent that materials such as tapes do not become displaced more than a total for both edges 1/8 inch from their initial position, disregarding movement due to slack or stretch which does not produce a separation of materials, and there is to be no evidence of other damage which would cause it to be unusable.

Collapse Test

Sec. 10.118. (a) **General.** Duct sections with joints assembled in accordance with the manufacturer's instructions shall resist collapse, damage and excessive deformation when subjected to negative pressure to two and one-half times the manufacturer's rated negative pressure, but not less than a negative pressure of 1 1/4-inch water column when tested as provided in this section.

(b) **Samples.** Sections of duct previously untested are to be used for the test. Samples 8 feet long are to be selected and prepared in accordance with Section 10.114 (b) and (c). The arrangement of the samples for test and the instrumentation are to be as for the rupture test. A means for creating and maintaining a negative pressure in the test sample is to be connected to the air tap.

(c) **Performance.** The negative air pressure in the test sample is to be maintained at the designated test pressure for a period of one hour. The sample is not to collapse; any joining material is to remain intact to the extent that materials such as tapes do not become displaced more than a total for both edges 1/8 inch from their initial position, disregarding movement due to slack or stretch which does not produce a separation of materials, and there is to be no evidence of other damage which would cause it to be unusable. Any reduction in external and internal cross-sectional area is not to exceed 20 percent at any time during the test.

Tension Test

Sec. 10.119. (a) **Sample.** Samples previously untested are to be used for test. Samples 8 feet long are to be selected and prepared in accordance with Section 10.114 (b) and (c). Suitable steel collars, if not part of the assembly, are to be attached to each end of the test sample in accordance with the manufacturer's instructions. One end collar is then to be secured to an overhead support so as to allow the sample to be suspended vertically. A 25-pound weight is to be attached to the lower end collar and allowed to remain for 24 hours.

(b) **Performance.** Observations are to be made during and following the application of the test load. The sample is not to rupture, tear, rip, collapse or separate; any joining material is to remain intact to the extent that materials such as tapes do not become displaced more than a total for both edges of $^1/_8$ inch from their initial position, disregarding movement due to slack or stretch which does not produce a separation of materials, and there is to be no evidence of other damage to the sample which would cause it to be unusable.

Torsion Test

Sec. 10.120. (a) **General.** Sections of flexible ducts and the joint between sections shall, when tested in accordance with these requirements, resist damage when subjected to a torque of 25 foot-pounds or a torque sufficient to produce an angular rotation of 180 degrees, whichever occurs first.

(b) **Sample.** Samples previously untested are to be tested. Samples 8 feet long are to be selected and prepared in accordance with Section 10.119 (a) except that a means to apply a torque to the lower end collar is to be provided. The test is to be conducted by first applying the test torque so as to rotate the bottom end clockwise, release the torque, and return the end to its initial position; then apply the test torque so as to rotate the bottom end counterclockwise, release the torque, and return the end to its initial position. This test series is to be repeated five times.

(c) **Performance.** Observations to be made during and following the application of the torque shall be as specified in Section 10.119 (b).

Bending Test

Sec. 10.121. (a) **Sample.** Samples previously untested are to be tested. Samples at least 8 feet long are to be selected and prepared in accordance with Sections 10.114 (b) and 10.115 (c). The sample is to be bent through a 180-degree arc around a test mandrel having a diameter equal to the inside of the duct. The test is to be repeated five times, each time returning the test sample to its original position.

(b) **Performance.** Observations are to be made during and following the test. The sample is to be capable of being bent around the mandrel and is not to rupture, break, tear, rip, collapse or separate; any reduction in internal cross-sectional area is not to exceed 20 percent at any time during the test; any joining material is to remain intact, and there is to be no evidence of other damage to the sample which would cause it to be unusable.

Leakage Test

Sec. 10.122. (a) **Sample.** The samples individually subjected to the tests for static load, impact, rupture, collapse, bending, tension and torsion, as appropriate for the product under investigation, are to be subjected to test for leakage. The arrangement for test and the instrumentation are to be as for the rupture test, except the water manometer is to be one which may be read directly to 0.01-inch water column. Samples longer than 8 feet are to be reduced in length to provide a test sample 8 feet long. An air meter is to be placed in the air-supply system between the supply source and the test sample. The meter is to indicate the total volume of air supplied to the sample over the period of the test. The meter is to be accurate within plus or minus 0.50 cubic foot under the conditions of the test. The volume within the test sample is to be calculated, based on inside measurements, to the nearest 1/16 inch.

(b) **Performance.** An air pressure of not less than 0.50-inch water column is to be maintained in the test sample for a period of one hour. The total volume of air recorded by the air meter from the time beginning with the establishment of the test pressure in the sample, to the end of the test period, is not to exceed 20 multiplied by the volume of the sample.

Marking

Sec. 10.123. Each piece of duct material shall carry the manufacturer's or vendor's identification, the rated air velocity, rated negative and positive pressures, and specific information relative to fabricating and joining material and methods. In addition, each piece of material for the field fabrication of air ducts shall be marked with information covering the maximum and minimum dimension of ducts to be made therefrom and each piece of rigid duct material shall carry the manufacturer's recommended support spacings.

Detailed information relative to the fabricating and joining materials and methods to be employed for a duct may be included in instructions packaged with each carton of duct material. If this is done, the marking on the duct material is to identify the joint treatment to be employed. Furthermore, the marking on the instructions is to be referenced to that treatment.

Each material furnished separately for use in fabrication of an air-duct system, such as tape, cement, adhesive, etc., shall carry sufficient identification to associate it with the marking on the duct material and the manufacturer's or vendor's installation instructions.

All required markings shall be grouped and appropriately located on each piece at intervals of 10 feet. Markings shall be reasonably permanent, as afforded by printing or stenciling with waterproof ink or paint on the surface of the material or on labels not adversely affected by water, attached to the material by means of suitable nonwater-soluble adhesive.

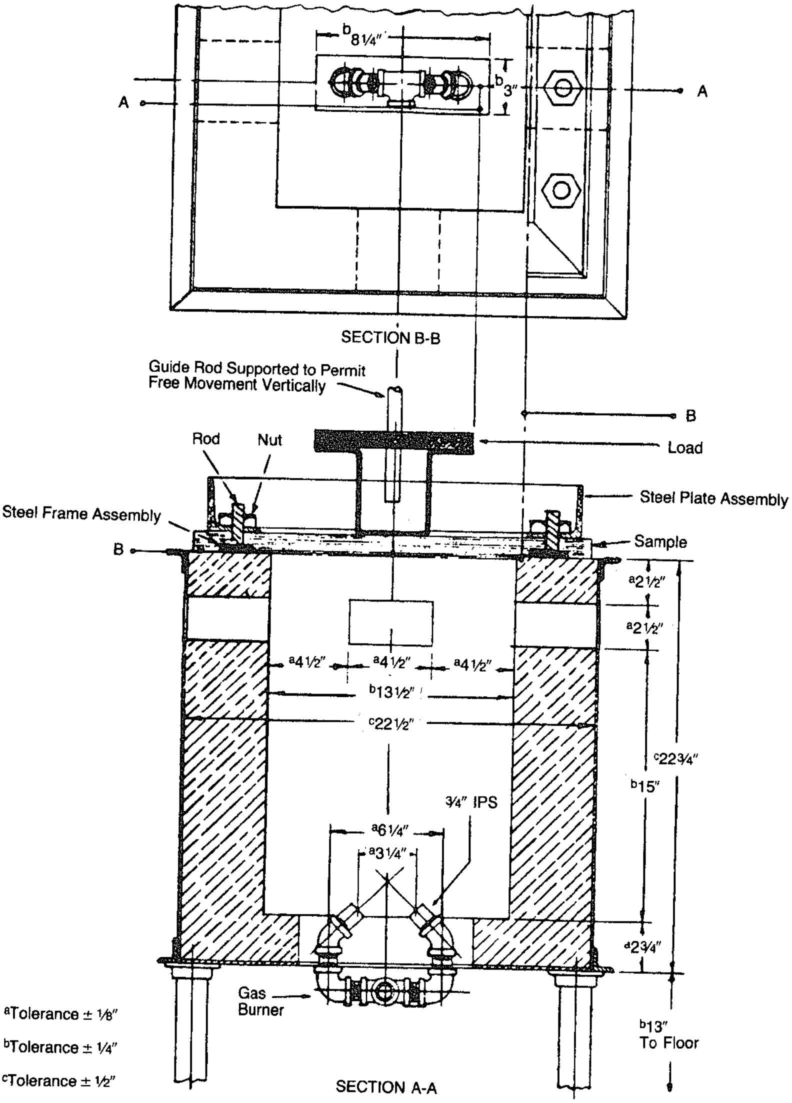
If a manufacturer produces material at more than one factory, each individual piece or assembly shall have a distinctive marking, which may be in code, by which it may be identified as the product of a particular factory.

TABLE NO. 10-1-A

TESTS	AIR DUCTS		JOINING MATERIALS
	Rigid	Flexible	
Surface-burning characteristics	X	X	—
Flame resistance	—	—	X
Flame penetration	X	X	—
Burning	X	X	—
Corrosion (see Note)	X	X	X
Mold Growth & humidity	X	X	X
Temperature	X	X	—
Puncture	X	X	—
Static load	X	—	—
Impact	X	X	—
Erosion	X	X	—
Pressure	X	X	—
Collapse	X	X	—
Tension	—	X	—
Torsion	—	X	—
Bending	—	X	—
Leakage	X	X	—

X = Test applicable.
— = Test not applicable.

NOTE: Applicable to parts of metals not inherently corrosion resistant.



aTolerance ± ⅛"

bTolerance ± ¼"

cTolerance ± ½"

FIGURE NO. 10-1-1
FLAME PENETRATION TEST

UNIFORM MECHANICAL CODE STANDARD NO. 10-2
STANDARD FOR METAL DUCTS

Based on the First Edition, 1985 HVAC Duct Construction Standards, Metal and Flexible, Published by the Sheet Metal and Air-Conditioning Contractors National Association.

See Section 1002 (a), Uniform Mechanical Code

Scope

Sec. 10.201. The performance criteria and requirements herein contemplate a duct that is a structural assembly having the capacity to support occupant health and safety while minimizing its own contribution to property damage under emergency conditions. Ducts can supply fresh or treated air in support of life and health, can convey products of combustion away from a fire zone, can maintain a pressure differential that facilitates evacuation and reduces the spread of fire and smoke and can facilitate fire-fighter access to a fire source.

Definitions

Sec. 10.202. CLOSURE is the joining components on duct surfaces that are subjected to a pressure differential across the duct wall, including mechanical locks and metallic and nonmetallic materials used as fillers or sealers whether on straight sections of ducts or fittings or used in connection of duct or fitting to other apparatus. Closure shall also pertain to penetrations of duct walls (such as by screws, rivets, pipes, electrical conduits, etc.).

CLOSURE FAILURE is any structural failure at a closure and also any loss of adhesive bond, creep, displacement or other deterioration of closure materials and methods that results in an increase in air leakage above an allowable level and any behavior contributing to accelerated aging of the closure systems.

DUCT ASSEMBLY is the completed composite connected assembly of straight sections, fittings and accessories attached to or occurring in the perimeter of an air passageway that is used for supply air, exhaust air or recirculated air mode. The passageway need not be continuous. **Note:** Where apparatus, ceiling plenums, room boundaries, shafts, air terminals, etc., form a part of the passageways, such are not subject to the performance requirements in this standard but are not prohibited from being made subject to similar requirements.

METAL DUCT is a duct constructed of galvanized steel, uncoated steel, stainless steel or aluminum material of commercial grade. Accessories and reinforcements are not required by this standard to be of the same material as the duct wall but they must be electrolytically compatible and shall not reduce the performance levels for strength and tight closure of ducts.

STRUCTURAL FAILURE is any visible and measurable rupture, collapse, buckling or other permanent deformation or separation of the elements in the duct assembly.

Performance Requirements for Ducts

Sec. 10.203. (a) **Pressure.** Structural failure or closure failure of duct assembly shall not occur at 150 percent of the designed operating pressure classification when supported at the maximum recommended support spacing.

(b) **Support Spacing.** Structural failure or closure failure of duct assembly shall not occur when supported at twice the maximum recommended support spacing and atmospheric pressure is maintained inside the ducts.

(c) **Deflection, Longitudinal.** The maximum allowable deflection of rectangular duct walls at design pressure classification shall not exceed the following:

DUCT DIMENSION	DEFLECTION
12″ down	1/2″
13″ to 18″	5/8″
19″ to 24″	3/4″
over 24″	1″

The deflection reference plane is that passing through two adjacent corners of the duct. For cross-broken ducts the measurement point shall be on the center-line of the duct at a point one eighth of the duct width or reinforcement interval or joint spacing if unreinforced, whichever is greater, from the intersection of the cross breaks. For cross-broken ducts the allowable wall deflection shall be increased by 50 percent of the deflection "set" measured at atmospheric pressure level in the duct.

(d) **Deflection, Transverse.** The maximum allowable deflection for rectangular duct transverse joint systems and intermediate reinforcements shall be 1/4 inch for duct widths of 100 inches or less and shall be 0.3 percent of the span for greater widths. In any case, the allowable deflection shall not be construed as permitting such members to exceed 60 percent of their yield stress.

(e) **Allowable Stress.** Loads imposed by fabricated duct weight designed pressure differential across the duct wall, bending moment created by supports and 1/2 pound per square foot of insulation weight shall not exceed 60 percent of the yield stress of the metals in the duct and its connections. Other internal and external loads are not accounted for by this standard.

(f) **Cyclical Loading Resistance.** Duct assemblies shall be capable of withstanding a daily on-off cycle of operation without structural failure.

(g) **Airtightness.** Closures for ducts shall be substantially airtight.

Support Requirements for Ducts

Sec. 10.204. (a) **Method and Interval.** The support spacing interval and method of contact with the duct assembly shall be selected to avoid structural failure or closure failure in the duct.

(b) **Allowable Stress in Supports.** Supports shall not be subjected to more than 60 percent of their yield stress.

(c) **Safety Factor.** The upper attachment of a duct suspension (hanging) system to a building structure shall have a safety factor of at least 4 based on ultimate failure (pullout) load.

(d) **Loading.** Supports shall account for loads identified in Section 10.203 (a).

(e) **Fastening Loads.** The location and arrangement of all fastenings in the support system shall be selected to avoid failure in tensile, compressive, shear and flexure modes.

(f) **Corrosion Control.** The support system shall not cause corrosion by galvanic (electrolytic) action at points of contact with the duct.

(g) **Character of Support System.** The support system shall not penetrate enclosures containing fluids or electrical wiring in such a manner as to create a hazard nor shall they penetrate a load-bearing member in such a manner as to cause excessive loading on the member.

Complying Systems

Sec. 10.205. Tables Nos. 10-2-A through 10-2-Q typify duct construction conforming with this standard. Throughout the tables in this standard, the minimum thickness in inches for galvanized sheet gage numbers is used.

TABLE NO. 10-2-A—RECTANGULAR DUCT HANGERS, MINIMUM SIZE

MAXIMUM HALF OF DUCT PERIMETER	Pair at 10 Ft. Spacing		Pair at 8 Ft. Spacing		Pair at 5 Ft. Spacing		Pair at 4 Ft. Spacing	
	STRAP	WIRE/ROD	STRAP	WIRE/ROD	STRAP	WIRE/ROD	STRAP	WIRE/ROD
$\frac{P}{2}$ = 30″	1″ × 0.030 (1″ × 22 ga.)	10 ga. (.135″)	1″ × 0.030 (1″ × 22 ga.)	10 ga. (.135″)	1″ × 0.030 (1″ × 22 ga.)	12 ga. (.106″)	1″ × 0.030 (1″ × 22 ga.)	12 ga. (.106″)
$\frac{P}{2}$ = 72″	1″ × 0.047 (1″ × 18 ga.)	3/8″	1″ × 0.036 (1″ × 20 ga.)	1/4″	1″ × 0.030 (1″ × 22 ga.)	1/4″	1″ × 0.030 (1″ × 22 ga.)	1/4″
$\frac{P}{2}$ = 96″	1″ × 0.058 (1″ × 16 ga.)	3/8″	1″ × 0.047 (1″ × 18 ga.)	3/8″	1″ × 0.036 (1″ × 20 ga.)	3/8″	1″ × 0.030 (1″ × 22 ga.)	1/4″
$\frac{P}{2}$ = 120″	1 1/2″ × 0.058 (1 1/2″ × 16 ga.)	1/2″	1″ × 0.058 (1″ × 16 ga.)	3/8″	1″ × 0.047 (1″ × 18 ga.)	3/8″	1″ × 0.036 (1″ × 20 ga.)	1/4″
$\frac{P}{2}$ = 168″	1 1/2″ × 0.058 (1 1/2″ × 16 ga.)	1/2″	1″ × 0.058 (1 1/2″ × 16 ga.)	1/2″	1″ × 0.058 (1″ × 16 ga.)	3/8″	1″ × 0.047 (1″ × 18 ga.)	3/8″
$\frac{P}{2}$ = 192″	—	1/2″	1 1/2″ × 0.058 (1 1/2″ × 16 ga.)	1/2″	1″ × 0.058 (1″ × 16 ga.)	3/8″	1″ × 0.058 (1″ × 16 ga.)	3/8″
$\frac{P}{2}$ = 193″ up		SPECIAL ANALYSIS REQUIRED						

WHEN STRAPS ARE LAP JOINED USE THESE MINIMUM FASTENERS:	SINGLE HANGER MAXIMUM ALLOWABLE LOAD	
	STRAP	WIRE OR ROD (Dia.)
1″ × 0.047″, 0.036″, 0.030″ - two No. 10 or one 1/4″ bolt 1″ × 0.058″ - two 1/4″ dia. 1 1/2″ × 0.058″ - two 3/8″ dia. Place fasteners in series, not side by side.	1″ × 0.030″ - 260 lbs. 1″ × 0.036″ - 320 lbs. 1″ × 0.047″ - 420 lbs. 1″ × 0.058″ - 700 lbs. 1 1/2″ × 0.058″ - 1100 lbs.	0.106″ - 80 lbs. 0.135″ - 120 lbs. 0.162″ - 160 lbs. 1/4″ - 270 lbs. 3/8″ - 680 lbs. 1/2″ - 1250 lbs. 5/8″ - 2000 lbs. 3/4″ - 3000 lbs.

NOTES:

1. Dimensions other than gage are in inches.
2. Tables allow for duct weight 1 lb./sf insulation weight normal reinforcement and trapeze weight but no external loads.
3. Straps are galvanized steel; other materials are uncoated steel.
4. Allowable loads for P/2 assume that ducts are 0.058 (16 ga.) maximum, except that when maximum duct dimension (w) is over 60″ then P/2 maximum is 1.25 w.
5. For trapeze sizes see Table No. 10-2-B.
6. Twelve, 10 or 8 ga. wire is steel of black-annealed, bright basic or galvanized type.

TABLE NO. 10-2-B—ALLOWABLE LOADS FOR TRAPEZE ANGLES
(For Rectangular Ducts)

LENGTH	1 x 1 x 0.056" (16 ga.)	1 x 1 x ⅛"	1½ x 1½ x 0.058" (16 ga.)	1½ x 1½ x ⅛"	1½ x 1½ x 3/16"	1½ x 1½ x ¼" or 2 x 2 x ⅛"	2 x 2 x 3/16"	2 x 2 x ¼"	2½ x 2½ x 3/16"	2½ x 2½ x ¼"
18"	80	150	180	350	510	650	940	1230	1500	1960
24"	75	150	180	350	510	650	940	1230	1500	1960
30"	70	150	180	350	510	650	940	1230	1500	1960
36"	60	130	160	340	500	620	920	1200	1480	1940
42"	40	110	140	320	480	610	900	1190	1470	1930
48"	—	80	110	290	450	580	870	1160	1440	1900
54"	—	40	70	250	400	540	840	1120	1400	1860
60"	—	—	—	190	350	490	780	1060	1340	1800
66"	—	—	—	100	270	400	700	980	1260	1720
72"	—	—	—	—	190	320	620	900	1180	1640
78"	—	—	—	—	80	210	500	790	1070	1530
84"	—	—	—	—	—	80	380	660	940	1400
96"	—	—	—	—	—	—	—	320	600	1060
108"	—	—	—	—	—	—	—	—	150	610
Loads above assume that a hanger rod is 6" max. distance from duct side.										

TABLE NO. 10-2-C—ROUND DUCT HANGERS

DUCT DIA.	MAXIMUM SPACING	WIRE DIA.	ROD	STRAP
10"dn	12'	One 12 ga.	¼"	1" × 0.030 (22 ga.)
11-18"	12'	Two 12 ga. or One 8 ga.	¼"	1" × 0.030 (22 ga.)
19-24"	12'	Two 10 ga.	¼"	1" × 0.030 (22 ga.)
25-36"	12'	Two 8 ga.	⅜"	1" × 0.036 (20 ga.)
37-50"	12'	→	Two ⅜"	Two 1" × 0.036 (20 ga.)
51-80"	12'	→	Two ⅜"	Two 1" × 0.047 (18 ga.)
81-94"	12'	→	Two ⅜"	Two 1" × 0.058 (16 ga.)

TABLE NO. 10-2-D—FLAT OVAL DUCT CONSTRUCTION

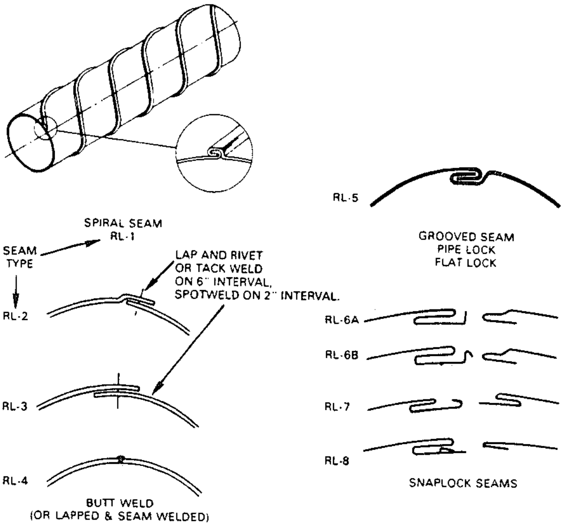
	INCHES (GAGE)		
DUCT WIDTH	Spiral Lock Seam Duct	Longitudinal Seam Duct	Fittings
To 24"	0.024 (24)	0.036 (20)	0.036 (20)
25" to 36"	0.030 (22)	0.036 (20)	0.036 (20)
37" to 48"	0.030 (22)	0.047 (18)	0.047 (18)
49" to 60"	0.036 (20)	0.047 (18)	0.047 (18)
61" to 70"	0.036 (20)	0.058 (16)	0.058 (16)
71" and up	0.047 (18)	0.058 (16)	0.058 (16)

TABLE NO. 10-2-E—ROUND DUCT GAGE SELECTION FOR GALVANIZED STEEL

DUCT DIAMETER (In Inches)	MAXIMUM 2″ W.G. STATIC POSITIVE		MAXIMUM 10″ W.G. STATIC POSITIVE		MAXIMUM 2″ W.G. STATIC NEGATIVE	
	SPIRAL SEAM Inches (Gage)	LONGITUDINAL SEAM Inches (Gage)	SPIRAL SEAM Inches (Gage)	LONGITUDINAL SEAM Inches (Gage)	SPIRAL SEAM Inches (Gage)	LONGITUDINAL SEAM Inches (Gage)
3 thru 8	0.016 (28)	0.016 (28)	0.019 (26)	0.024 (24)	0.016 (28)	0.024 (24)
9 thru 14	0.016 (28)	0.019 (26)	0.019 (26)	0.024 (24)	0.019 (26)	0.024 (24)
15 thru 26	0.019 (26)	0.024 (24)	0.024 (24)	0.030 (22)	0.024 (24)	0.030 (22)
27 thru 36	0.024 (24)	0.030 (22)	0.030 (22)	0.036 (20)	0.030 (22)	0.036 (20)
37 thru 50	0.030 (22)	0.036 (20)	0.036 (20)	0.036 (20)	0.036 (20)	0.047 (18)
51 thru 60	0.036 (20)	0.047 (18)	0.047 (18)	0.047 (18)	0.047 (18)	0.058 (16)
61 thru 84	0.047 (18)	0.058 (16)	0.047 (18)	0.058 (16)	0.058 (16)	0.070 (14)

(Continued)

TABLE NO. 10-2-E—ROUND DUCT GAGE SELECTION FOR GALVANIZED STEEL—(Continued)

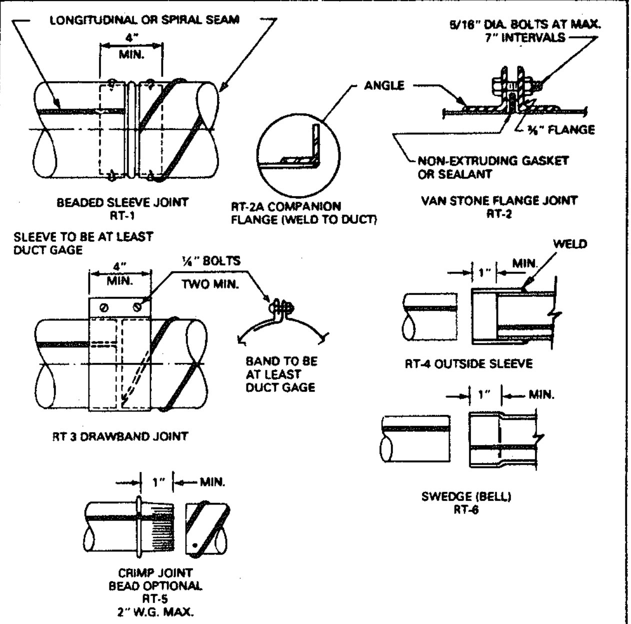

SPIRAL SEAM
RL-1
SEAM TYPE
RL-2
LAP AND RIVET OR TACK WELD ON 6" INTERVAL, SPOTWELD ON 2" INTERVAL.
RL-3
RL-4
BUTT WELD (OR LAPPED & SEAM WELDED)
RL-5
GROOVED SEAM
PIPE LOCK
FLAT LOCK
RL-6A
RL-6B
RL-7
RL-8
SNAPLOCK SEAMS

PRESSURE CLASS	SEAM TYPE PERMITTED
Positive	
To +10" w.g.	RL-1, 4, 5 (2*, 3*)
To +3" w.g.	RL-1, 2, 3, 4, 5
To +2" w.g.	ALL
NEGATIVE	
To -2" w.g.	RL-1, 2, 3, 4, 5
To -1" w.g.	ALL

*ACCEPTABLE IF SPOTWELDED ON 1" INTERVALS.

SPIRAL AND LONGITUDINAL SEAMS

TABLE NO. 10-2-E—ROUND DUCT GAGE SELECTION FOR GALVANIZED STEEL—(Continued)


LONGITUDINAL OR SPIRAL SEAM
4" MIN.
ANGLE
5/16" DIA. BOLTS AT MAX. 7" INTERVALS
¾" FLANGE
NON-EXTRUDING GASKET OR SEALANT
SLEEVE TO BE AT LEAST DUCT GAGE
4" MIN.
¼" BOLTS TWO MIN.
BAND TO BE AT LEAST DUCT GAGE
WELD
1" MIN.
1" MIN.
1" MIN.

BEADED SLEEVE JOINT
RT-1

RT-2A COMPANION FLANGE (WELD TO DUCT)

VAN STONE FLANGE JOINT
RT-2

RT 3 DRAWBAND JOINT

RT-4 OUTSIDE SLEEVE

SWEDGE (BELL)
RT-6

CRIMP JOINT
BEAD OPTIONAL
RT-5
2" W.G. MAX.

ON JOINTS RT-1, 3, 4, and 6 SCREWS MUST BE USED AT UNIFORM INTERVALS 15" MAXIMUM ALONG THE CIRCUMFERENCE; THREE SCREWS MINIMUM ON 14" OR LESS DIAMETER.

MIN. FLANGE SIZES FOR RT-2 and 2A
1" × 1" × 10 GA on 14" MAX. DIA.
1½" × 1½" × ⅛" DIA. OVER 14"

LONGITUDINAL OR SPIRAL SEAM DUCT IS ACCEPTABLE FOR ALL JOINTS EXCEPT RT-4 AND 6 (FOR LONGITUDINAL ONLY)

TRANSVERSE JOINTS

TABLE NO. 10-2-G—RECTANGULAR DUCT TRANSVERSE REINFORCEMENT FOR DUCT MATERIAL THICKNESSES FROM 0.030″ (22 GA.) to 0.019″ (26 GA.)

Pressure Class (Water gage) →	1/2″	1/2″	1″	1″	2″	2″	1/2″	1/2″	1″	1″	2″	2″	1/2″	1/2″	1″	1″	2″	2″
Duct Thickness Inches (Gage) →	0.030″ (22)	0.030″ (22)	0.030″ (22)	0.030″ (22)	0.030″ (22)	0.030″ (22)	0.024″ (24)	0.024″ (24)	0.024″ (24)	0.024″ (24)	0.024″ (24)	0.024″ (24)	0.019″ (26)	0.019″ (26)	0.019″ (26)	0.019″ (26)	0.019″ (26)	0.019″ (26)
Duct Dimensions ↓																		
7″ dn.																		
8-10″																		
11, 12″																	A/5^{D}	A/8^{D}
13, 14″											A/5^{D}	A/8^{D}			A/10^{D}	A/8^{D}	A/5^{D}	A/4^{D}
15, 16″					A/10^{D}	A/8^{D}			A/10^{D}	A/8^{D}	A/5^{D}	A/8^{D}			A/5^{D}	A/8^{D}	A/5^{D}	A/4^{D}
17, 18″					A/10^{D}	A/8^{D}			A/10^{D}	A/8^{D}	A/5^{D}	A/8^{D}			A/5^{D}	A/8^{D}	A/5^{D}	A/4^{D}
19, 20″			A/10^{D}	A/8^{D}	A/5^{D}	B/8			A/10^{D}	A/8^{D}	A/5^{D}	A/4^{D}	A/10^{D}	A/8^{D}	A/5^{D}	A/8^{D}	A/5^{D}	A/4^{D}
21, 22″			A/10	A/8	A/5	B/8	A/10	A/8	A/10	A/8	A/5	A/4	A/10	A/8	A/5	A/4	A/5	A/4
23, 24″			B/10	B/8	B/5	C/8	A/10	A/8	B/10	B/8	B/5	B/4	A/10	A/8	A/5	A/4	B/5	B/4
25, 26″	A/10	A/8	B/10	B/8	B/5	C/8	A/10	A/8	A/5	B/8	B/5	B/4	A/10	A/8	A/5	A/4	B/5	B/4
27, 28″	B/10	B/8	C/10	C/8	C/5	B/4	B/10	B/8	B/5	C/8	C/5	B/4	B/5	B/8	B/5	B/4	B/2½	B/4
29, 30″	B/10	B/8	C/10	C/8	C/5	C/4	B/10	B/8	B/5	C/8	C/5	C/4	B/5	B/8	B/5	B/4	C/2½	C/4
31-36″	C/10	C/8	C/5	D/8	D/5	D/4	C/5	C/8	C/5	C/4	D/2½	D/4	C/5	C/4	C/5	C/4		
37-42″	D/5	D/8	D/5	D/4	E/5	E/4	D/5	D/8	D/5	D/4	E/2½	E/4	D/5	C/4	D/2½	D/4		
43-48″	D/5	D/8	E/5	D/4	E/2½	E/4	D/5	D/4	E/5	D/4	E/2½	E/2	D/5	D/4	D/2½	D/4		
49-54″	D/5	D/4	E/5	E/4	F/2½	F/2	D/5	D/4	E/2½	E/4	F/2½	F/2	D/5	D/4				
55-60″	E/5	E/4	F/5	F/4	G/2½	G/2	E/5	E/4	F/2½	F/4			E/2½	E/4				
61-72″	F/5	F/4	G/2½	G/4	H/2½	H/2	F/2½	F/4										
73-84″	H/5	G/4					G/2½	G/4										
85-96″	H/2½	H/4																
97″ up																		

Standing reinforcement is not required on duct sizes above this heavy line. Flat Slips and drives or other choice may be used. Flat Slips and Drives must not be less than one gage below duct gage and not less than 24 gage.

← NOT REQUIRED →

NOT ALLOWED

Flat slips and drives may be backed with stiffeners from Table No. 10-2-J and thereby qualified for this table. Where the superscript D occurs, the flat drive is accepted as Class A. See Table No. 10-2-K.

THIS NUMBER IS THE SPACING INTERVAL BETWEEN REINFORCEMENTS, IN FEET

THIS LETTER DENOTES TYPE OF REINFORCEMENT TO BE SELECTED FROM JOINT TABLES NOS. 10-2-I, 10-2-J OR 10-2-K

TABLE NO. 10-2-H—RECTANGULAR DUCT TRANSVERSE REINFORCEMENT FOR DUCT MATERIAL THICKNESSES FROM 0.058" (16 GA.) to 0.036" (20 GA.)

Pressure Class (Water gage) →	1/2"	1/2"	1"	1"	2"	2"	1/2"	1/2"	1"	1"	2"	2"	1/2"	1/2"	1"	1"	2"	2"
Duct Thickness Inches (Gage) →	0.058" (16)	0.058" (16)	0.058" (16)	0.058" (16)	0.058" (16)	0.058" (16)	0.047" (18)	0.047" (18)	0.047" (18)	0.047" (18)	0.047" (18)	0.047" (18)	0.036" (20)	0.036" (20)	0.036" (20)	0.036" (20)	0.036" (20)	0.036" (20)
Duct Dimensions ↓																		
7" dn.																		
8-10"																		
11, 12"																		
13, 14"																		
15, 16"																		
17, 18"																		
19, 20"																	B/10	B/8
21, 22"											B/10	B/8			A/10	A/8	B/10	B/8
23, 24"											C/10	C/8			B/10	B/8	B/10	C/8
25, 26"					C/10	C/8					C/10	C/8			B/10	B/8	C/10	C/8
27, 28"					C/10	C/8			C/10	C/8	C/10	C/8	B/10	B/8	C/10	C/8	C/5	C/8
29, 30"					D/10	D/8			C/10	C/8	D/10	D/8	B/10	B/8	C/10	C/8	C/5	D/8
31-36"			D/10	D/8	E/10	E/8	C/10	C/8	D/10	D/8	D/5	E/8	C/10	C/8	D/10	D/8	D/5	D/4
37-42"	D/10	D/8	E/10	E/8	E/5	E/8	D/10	D/8	E/10	D/8	E/5	E/4	D/10	D/8	D/5	D/8	E/5	E/4
43-48"	E/10	D/8	F/10	F/8	F/5	G/8	E/10	D/8	E/5	E/8	F/5	E/4	E/10	D/8	E/5	D/4	F/5	E/4
49-54"	E/10	E/8	G/10	F/8	G/5	F/4	E/10	E/8	E/5	F/8	G/5	F/4	D/5	E/8	E/5	E/4	F/2½	F/4
55-60"	F/10	F/8	F/5	G/8	H/5	G/4	F/10	F/8	F/5	G/8	H/5	G/4	E/5	F/8	F/5	F/4	G/2½	G/4
61-72"	H/10	G/8	H/5	G/4	I/5	H/4	F/5	G/8	H/5	G/4	H/2½	H/4	F/5	F/4	G/2½	G/4	H/2½	H/2
73-84"	H/5	H/8	I/5	H/4	I/2½	J/4	H/5	G/4	I/5	H/4	I/2½	J/4	H/5	G/4	H/2½	H/4	I/2½	I/2
85-96"	H/5	I/8	J/5	I/4	J/2½	K/4	H/5	H/4	I/2½	I/4	J/2½	J/2	H/5	H/4	I/2½	I/2	J/2½	J/2
97" up	H/5	H/4	J/2½	J/2	K/2½	K/2	H/5	H/4	J/2½	J/2	K/2½	K/2						

Standing reinforcement is not required on duct sizes above this heavy line. Flat Slips and drives or other choice may be used. Flat Slips and Drives must not be less than one gage below duct gage and not less than 24 gage.

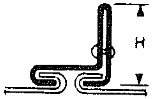
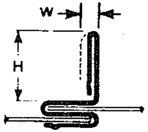
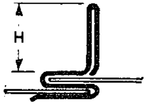
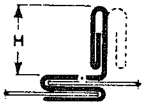
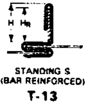
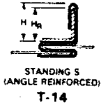
← NOT REQUIRED →

THIS NUMBER IS THE SPACING INTERVAL BETWEEN REINFORCEMENTS, IN FEET

THIS LETTER DENOTES TYPE OF REINFORCEMENT TO BE SELECTED FROM JOINT TABLES NOS. 10-2-I, 10-2-J OR 10-2-K

Flat slips and drives may be backed with stiffeners from Table No. 10-2-J and thereby qualified for this table.

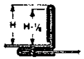
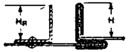
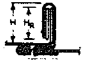
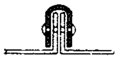
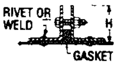
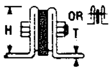
TABLE NO. 10-2-I—TRANSVERSE JOINT REINFORCEMENT FOR TABLES NO. 10-2-G AND NO. 10-2-H

MINIMUM RIGIDITY CLASS		 T-2 STANDING DRIVE SLIP		 T-10 STANDING S		 T-11 STANDING S		 T-12 STANDING S		 STANDING S (BAR REINFORCED) T-13  STANDING S (ANGLE REINFORCED) T-14	
	EI	H x T	WT/LF	H x T	WT/LF	H x T	WT/LF	H x T	WT/LF	H x T + HR	WT/LF
A	0.5	↑		↑		1/2 × 0.019″ (1/2 × 26 ga.)	.5	↑		↑	
B	1.0	1 1/8 × 0.019″ (1 1/8 × 26 ga.)	.5			1/2 × 0.030″ (1/2 × 22 ga.)	.7				
C	2.5	1 1/8 × 0.030″ (1 1/8 × 22 ga.,	.8	1 × 0.019″ (1 × 26 ga.)	.6	1 × 0.019″ (1 × 26 ga.)	.6				
D	5	NOT GIVEN		1 × 0.024″ (1 × 24 ga.)	.7	1 × 0.024″ (1 × 24 ga.)	.7	1 1/8 × 0.019″ (1 1/8 × 26 ga.)	.7		

E	10			1 1/8 × 0.036″ (1 1/8 × 20 ga.) w = 3/16″	.9	NOT GIVEN		1 1/8 × 0.047″ (1 1/8 × 18 ga.)	1.4	—	
F	15			1 5/8 × 0.030″ (1 5/8 × 22 ga.) w = 3/16″	1.0			1 1/2 × 0.024″ (1 1/2 × 24 ga.)	1.0	1 1/2 × 0.024″ (1 1/2 × 24 ga.) 1 1/2 × 1/8 Bar	1.5
G	25			1 5/8 × 0.047″ (1 5/8 × 18 ga.) w = 3/16″	1.5			1 1/2 × 0.047″ (1 1/2 × 18 ga.)	1.7	1 1/2 × 0.030″ (1 1/2 × 22 ga.) 1 1/2 × 1/8 Bar	1.6
H	50			NOT GIVEN				NOT GIVEN		1 1/2 × 0.036″ (1 1/2 × 20 ga.) 1 1/2 × 1 1/2 × 3/16	2.9
I	75									2 × 0.036″ (2 × 20 ga.) 2 × 2 × 1/8	2.9
J	100									2 × 0.036″ (2 × 20 ga.) 2 × 2 × 3/16	3.7
K	150									NOT GIVEN	
L	200	↓		↓		↓		↓		↓	

(Continued)

TABLE NO. 10-2-I—TRANSVERSE JOINT REINFORCEMENT FOR TABLES NO. 10-2-G AND NO. 10-2-H—(Continued)

* MINIMUM RIGIDITY CLASS		3" W.G. MAXIMUM  POCKET LOCK T-17  ANGLE REINFORCED POCKET LOCK T-19	 BAR REINFORCED POCKET LOCK T-18		 T-20 CAPPED FLANGE			 T-22 COMPANION ANGLES		 T-23 FLANGED	
	EI	H	LOCK T, DUCT T, HR	WT/LF	H x T	U	WT/LF	H x T	WT/LF	H x T	WT/LF
A	0.5		▲					▲		▲	
B	1.0				3/4 × 0.019" (26 ga.)	0.024" (24 ga.)	.4				
C	2.5	T-17 1"	0.019" (26 ga.) Lock on 0.019" (26 ga.)	.6	1 × 0.024" (24 ga.)	0.024" (24 ga.)	.5			1 × 0.024" (24 ga.)	1.0
D	5	T-17 1"	0.024" (24 ga.) Lock on 0.024" (24 ga.)	.7	1 × 0.030" (22 ga.)	0.030" (22 ga.)	.6			1 × 0.030" (22 ga.)	1.0

E	10	T-18 1"	0.030" (22 ga.) Lock 1 x 1/8 Bar	1.4	1½ × 0.024" (24 ga.)	0.030" (22 ga.)	.8	TWO 1 x 1/8	1.7	1 × 0.058" (16 ga.) 1½ × 0.024" (24 ga.)	1.0
F	15	T-17 1½"	0.030" (22 ga.) Lock	1.0	1½ × 0.036" (20 ga.)	0.036" (20 ga.)	1.0	↑		1½ × 0.030" (22 ga.) 1½ × 0.036" (20 ga.)	1.0 1.0
G	25	T-18 1½"	0.030" (22 ga.) Lock 1 1/2 x 1/8 Bar	1.6	↑	↑		TWO 1 1/4 x 1/8	2.1	1½ × 0.047' (18 ga.)	1.5
H	50	T-19 1½"	0.036" (20 ga.) Lock 1 1/2 x 3/16 Angle	2.9	2 × 0.058" (16 ga.)	0.036" (20 ga.)	1.5	TWO 1 1/2 x 1/8	2.6	2 × 0.047" (18 ga.)	1.5
I	75	T-19 1½"	0.036" (20 ga.) Lock 2 x 1/8 Angle	2.8	2 × 0.058" (16 ga.) **			TWO* 1 1/2 x 3/16	3.7	2 × 0.058" (16 ga.)	2.0
J	100	T-19 1½"	0.036" (20 ga.) Lock 2 x 3/16 Angle	3.5				TWO* 1 1/2 x 1/4	4.7	2 × 0.047" (18 ga.)	
K	150	T-19 1½"	0.036" (20 ga.) Lock 2 1/2 x 3/16 Angle	4.2				TWO* 2 x 3/16	4.9	WITH TIE RODS	
L	200		NOT GIVEN		↓			TWO* 2 x 1/4	6.5	↓	

Nominal EI equals number listed times 10^5.

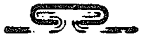
*Tie rod option also: Use Class H plus one tie rod.

(Continued)

TABLE NO. 10-2-I—TRANSVERSE JOINT REINFORCEMENT FOR TABLES NO. 10-2-G AND NO. 10-2-H—(Continued)

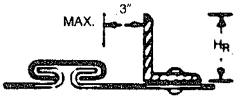
DUCT THICKNESS	Inches (Gage)	0.019″ to 0.030″ (26 to 22)	0.036″ (20)	0.047″ (18)	0.058″ (16)
Minimum Flat Slip and Drive Gage		0.024″ (24)	0.030″ (22)	0.036″ (20)	0.047″ (18)

By themselves flat-type slip connections and lap joints do not qualify as reinforcements. When backed by a stiffener from Table No. 10-2-J, the reinforcement is graded by the stiffener. See an exception for joint T-1 in Table No. 10-2-K. T-5, T-6 and T-7 are restricted to 2″ w.g. maximum service pressure.



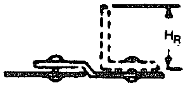
DRIVE SLIP

T-1



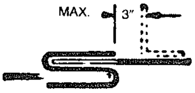
DRIVE SLIP —REINFORCED

T-3



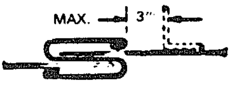
LAP

T-4



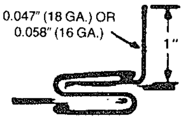
PLAIN "S" SLIP

T-5



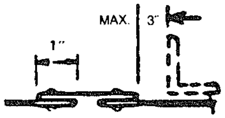
HEMMED "S" SLIP

T-6



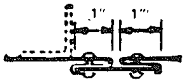
REINFORCED "S" SLIP

T-7



DOUBLE "S" SLIP

T-8

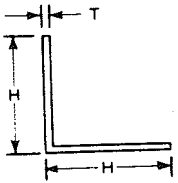
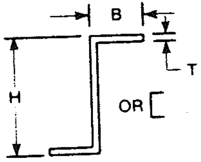
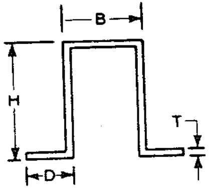
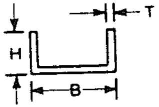


INSIDE SLIP JOINT

T-9

For pressure classes over 2″
water gage double S slips of 30″ length
or less shall be 0.024″ (No. 24 gage) minimum;
lengths over 30″ shall be 0.030″ (No. 22 gage) minimum.

TABLE NO. 10-2-J—INTERMEDIATE REINFORCEMENT

MINIMUM RIGIDITY CLASS		 ANGLE		 ZEE		 HAT SECTION		 CHANNEL	
	EI*	H x T (MIN)	WT/LF	H x B x T (MIN	WT/LF	H x B x D x T (MIN)	WT/LF	H x B x T (MIN)	WT/LF
A	0.5	↑		↑		↑		↑	
B	1.0			3/4 × 1/2 × 0.036″ (20 ga.)	.28				
C	2.5	1 × 0.047″ (18 ga.) 1 × 0.058″ (16 ga.) 3/4 x 1/8	.34 .44 .59	3/4 × 1/2 × 0.047 (18 ga.)	.36			3/4 × 3 × 0.047″ (18 ga.)	.81
D	5	1 1/4 × 0.047″ (18 ga.) 1 x 1/8	.45 .80	1 × 3/4 × 0.036″ (20 ga.)	.35			1 1/8 × 3 1/4 × 0.047″ (18 ga.) 1 × 3 × 0.047″ (18 ga.)	1.0

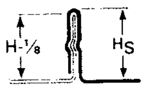
(Continued)

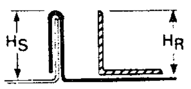
TABLE NO. 10-2-J—INTERMEDIATE REINFORCEMENT—(Continued)

E	10	1 1/4 x .090 1 1/2 × 0.058" (16 ga.)	.80 .66	1 x 3/4 x .090 1 1/2 × 3/4 × 0.036" (20 ga.)	.78 .41		.7	1 x 2 x 1/8	1.6
F	15	1 1/2 x 1/8*	1.23	1 x 3/4 x 1/8 1 1/2 × 3/4 × 0.047". (18 ga.)	1.03 .54	1 1/2 × 3/4 × 5/8 × 0.036" (20 ga.) 1 1/2 × 1 1/2 × 3/4 × 0.036" (20 ga.)	.7 1.1	1 1/4 × 3 1/2 × 0.058" (16 ga.) 1 1/8 x 3 x 1/8	1.32 2.1
G	25	1 1/2 x 3/16	.96	1 1/2 x 3/4 x 1/8 2 × 1 1/8 × 0.036" (20 ga.)	1.23 .6	1 1/2 × 3/4 × 5/8 × 0.058" (16 ga.) 1 1/2 × 1 1/2 × 3/4 × 0.047" (18 ga.) 2 × 1 × 3/4 × 0.036" (20 ga.)	.82 1.1 .90		
H	50	2 x 1/8	1.65	2 × 1 1/8 × 0.058" (16 ga.)	.94	1½ x 3/4 x 5/8 x 1/8 1½ x 1½ x 3/4 x .090 2 × 1 × 3/4 × 0.036" (20 ga.)	2.1 1.9 1.2	1.4 x 3	4.1
I	75	2 x 3/16	2.44	2 x 1 1/8 x .090	1.33	2 x 1 x 3/4 x .090 2 1/2 × 2 × 3/4 × 0.058" (16 ga.)	2.03 1.88	2 x 2 x 1/8 1.5 x 3	2.4 5.0
J	100	2 x 1/4 2 1/2 x 1/8	3.2 2.1	2 x 1 1/8 x 1/8 3 × 1 1/8 × 0.058" (16 ga.)	1.74 1.2	2 x 1 x 3/4 x 1/8 2½ x 2 x 3/4 x .090	2.63 2.67	1.6 x 4	5.4
K	150	2 1/2 x 3/16	3.1	3 x 1 1/8 x .090	1.64	2½ x 2 x 3/4 x 1/8 3 × 1 1/2 × 3/4 × 0.058" (16 ga.)	3.57 2.0	NOT GIVEN	
L	200	2 1/2 x 1/4	4.1	3 x 1 1/8 x 1/8	2.15	3 x 1½ x 3/4 x .090	2.82		

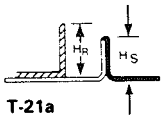
Nominal EI is number listed times 10^5 *See tie rod options.

TABLE NO. 10-2-K—TRANSVERSE JOINT REINFORCEMENT FOR TABLES NOS. 10-2-G, 2-H, 2-L, 2-N OR 2-O

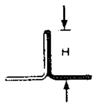




T-16



T-21a



MINIMUM RIGIDITY CLASS		T-15 STANDING SEAM		STANDING SEAM OR WELDED FLANGE REINFORCED						T-21 WELDED FLANGE	
				26 TO 22 GA. DUCT			20 TO 16 GA. DUCT				
	EI	Hs x T	WT/LF	Hs	H x H x T	WT/LF	Hs	H x H x T	WT/LF	Hs x T	WT/LF
A	0.5	1/2 × 0.024″ (24 ga.)	.2		↑			↑		1/2 × 0.030″ (22 ga.)	.1
B	1.0	3/4 × 0.024″ (24 ga.)	.3		↑			↑		1/2 × 0.058″ (16 ga.) 3/4 × 0.030″ (22 ga.)	.2 .2
C	2.5	1 × 0.024″ (24 ga.)	.5		↑			↑		3/4 × 0.047″ (18 ga.) 1 × 0.030″ (22 ga.)	.3
D	5	3/4 × 0.058″ (16 ga.) 1 × 0.036″ (20 ga.)	.3 .5	1″	1 × 1 × 0.058″ (16 ga.)	1.0		↑		1 × 0.047″ (18 ga.) 1 1/4 × 0.030″ (22 ga.)	.4 .3

(Continued)

TABLE NO. 10-2-K—TRANSVERSE JOINT REINFORCEMENT FOR TABLES NOS. 10-2-G, 2-H, 2-L, 2-N, OR 2-0—(Continued)

E	10	1 × 0.058″ (16 ga.) 11/2 × 0.024″ (24 ga.)	.7 .7	1″	1 x 1 x 1/8	1.4	1″	1 × 1 × 0.058″ (16 ga.)	1.0	11/4 × 0.047″ (18 ga.) 11/2 × 0.030″ (22 ga.)	.5 .4
F	15	11/2 × 0.036″ (20 ga.)	.7	1½″	11/2 × 11/2 × 0.058″ (16 ga.)	1.8	1¼″	11/4 × 11/4 × 0.058″ (16 ga.)	1.7	11/4 × 0.058″ (16 ga.) 11/2 × 0.036″ (20 ga.)	.6 .4
G	25	11/2 × 0.047″ (18 ga.)	.8	1½″ 1½″	1½ x 1½ x 1/8 2 × 2 × 0.058″ (16 ga.)	2.0	1½″	1½ x 1½ x 1/8	2.4	11/2 × 0.058″ (16 ga.)	.7
H	50	SEE T-16 AND TIE ROD OPTIONS		1½″	2 x 2 x 1/8*	2.7	1½″ 1½″	1½ x 1½ x 3/16 2 × 2 × 0.058″ (16 ga.)	2.8 2.0	SEE T-21a AND TIE ROD OPTIONS TABLE NO. 10-2-Q	
I	75	↓			↑		1½″	2 x 2 x 1/8*	2.7	↓	
J	100	↓		1½″	2 x 2 x 3/16*	3.5	1½″	2 x 2 x 3/16*	3.5	↓	
K	150	↓		1½″	2½ x 2½ x 3/16*	4.1		↑		↓	
L	200	↓		1½″	2½ x 2½ x 1/4	5.3	1½″	2½ x 2½ x 3/16*	4.1	↓	

Nominal EI equals number listed times 10^5. *See tie rod option.

TABLE NO. 10-2-K—JOINT T-1 FLAT DRIVE AS CLASS A REINFORCEMENT—(Continued)

STATIC PRESSURE	MAXIMUM ALLOWABLE DUCT WIDTH DIMENSION (Inches)	MAXIMUM REINFORCEMENT SPACING INTERVAL (Feet)
1/2″ w.g.	20	10
1″ w.g.	20	8
	14	10
2″ w.g.	20	5
	18	8
3″ w.g.	18	8
4″ w.g.	16	5
	12	8
6″ w.g.	12	5

Note: Where Tables Nos. 10-2-G, H, L, M and N require Class A reinforcement, joint T-1 is acceptable as Class A within these parameters and without supplemental reinforcement from Table No. 10-2-J.

TABLE NO. 10-2-L—RECTANGULAR DUCT REINFORCEMENT

3″ W.G. STATIC POS. OR NEG.	0.058″ (16 GAGE)	0.047″ (18 GAGE)	0.036″ (20 GAGE)	0.030″ (22 GAGE)	0.024″ (24 GAGE)
DUCT DIMENSION		MINIMUM CLASS		MAXIMUM SPACING	
10″ down	Not required	Not required	Not required	Not required	Not required
11″ to 12″	↓	↓	↓	↓	A @ 8′
13″ to 14″	↓	↓	↓	A @ 8′	A @ 5′
15″ to 16″	↓	↓	A @ 8′	A @ 8′	A @ 5′
17″ to 18″	↓	↓	A @ 8′	A @ 8′	A @ 5′
19″ to 20″	↓	B @ 10′	B @ 8′	A @ 5′	A @ 5′
21″ to 22″	↓	C @ 10′	B @ 8′	B @ 5′	B @ 5′
23″ to 24″	↓	C @ 10′	B @ 5′	B @ 5′	B @ 5′
25″ to 26″	D @ 10′	D @ 10′	C @ 5′	C @ 5′	C @ 5′
27″ to 28″	D @ 10′	D @ 10′	C @ 5′	C @ 5′	C @ 4′
29″ to 30″	D @ 10′	D @ 8′	C @ 5′	C @ 5′	C @ 4′
31″ to 36″	E @ 8′	E @ 5′	E @ 5′	D @ 4′	D @ 4′
37″ to 42″	E @ 5′	E @ 5′	E @ 5′	E @ 4′	E @ 3′
43″ to 48″	G @ 5′	G @ 5′	F @ 4′	E @ 3′	E @ 2½′
49″ to 54″	H @ 5′	H @ 5′	G @ 3′	G @ 3′	E @ 2½′
55″ to 60″	H @ 5′	H @ 4′	G @ 3′	G @ 2½′	G @ 2½′
61″ to 72″	I @ 4′	H @ 3′	H @ 3′	H @ 2½′	F @ 2*
73″ to 84″	J @ 3′	J @ 3′	J @ 2½′	I @ 2′	
85″ to 96″	L @ 3′	K @ 2½′	J @ 2′	G @ 2½′*	
Over 96″		H @ 2½′*			

Notes:

1. Reinforcement class refers to transverse joint or intermediate members having stiffness and other characteristics indicated in tables.
2. Joint spacing is unrestricted.
3. Reinforcement is evaluated for each duct side separately. When required on four sides, corners shall be tied. When required on two sides, they shall be tied with rods or angles at the ends on 4-, 6- and 10-inch pressure classes.
4. The same gage of metal shall be used on all four sides of a cross section.
5. *Plus tie rods at 48 inches maximum along joints and intermediates. Tie rod sizes: 1/4-inch diameter for 36-inch length or less, 3/8-inch diameter over 36 inches. Space at even divisions of duct width.

TABLE NO. 10-2-M—RECTANGULAR DUCT REINFORCEMENT

4″ W.G. STATIC POSITIVE	0.058 (16 GAGE)	0.047 (18 GAGE)	0.036 (20 GAGE)	0.030 (22 GAGE)	0.024 (24 GAGE)
DUCT DIMENSION	MINIMUM CLASS MAXIMUM SPACING				
8″ down	Not required	Not required	Not required	Not required	Not required
9″ to 10″	↓	↓	↓	↓	A @ 5′
11″ to 12″	↓	↓	↓	A @ 10′	A @ 5′
13″ to 14″	↓	↓	A @ 10′	A @ 8′	A @ 5′
15″ to 16″	↓	↓	A @ 10′	A @ 5′	A @ 5′
17″ to 18″	↓	B @ 10′	B @ 8′	A @ 5′	A @ 5′
19″ to 20″	C @ 10′	C @ 10′	B @ 8′	B @ 5′	B @ 5′
21″ to 22″	C @ 10′	C @ 10′	B @ 5′	B @ 5′	B @ 4′
23″ to 24″	D @ 10′	D @ 10′	C @ 5′	C @ 5′	C @ 4′
25″ to 26″	D @ 10′	D @ 10′	C @ 5′	C @ 5′	C @ 4′
27″ to 28″	E @ 10′	E @ 8′	D @ 5′	D @ 5′	D @ 4′
29″ to 30″	E @ 10′	E @ 8′	D @ 5′	D @ 5′	D @ 4′
31″ to 36″	E @ 5′	E @ 5′	E @ 5′	E @ 4′	D @ 3′
37″ to 42″	F @ 5′	F @ 5′	F @ 4′	E @ 3′	E @ 2½′
43″ to 48″	G @ 5′	G @ 5′	F @ 3′	F @ 3′	E @ 2′
49″ to 54″	H @ 5′	H @ 4′	G @ 3′	G @ 2½′	F @ 2′
55″ to 60″	I @ 5′	H @ 3′	H @ 3′	H @ 2½′	G @ 2′
61″ to 72″	I @ 3′	I @ 3′	I @ 2½′	H @ 2′	
73″ to 84″	K @ 3′	J @ 2½′	J @ 2′		
85″ to 96″	L @ 2½′	K @ 2′	K @ 2′		
Over 96″		H @ 2½′*			

Notes:

1. Reinforcement class refers to transverse joint or intermediate members having stiffness and other characteristics indicated in tables.
2. Joint spacing is unrestricted.
3. Reinforcement is evaluated for each duct side separately. When required on four sides, corners shall be tied. When required on two sides, they shall be tied with rods or angles at the ends on 4-, 6- and 10-inch pressure classes.
4. The same gage of metal shall be used on all four sides of a cross section.
5. *Plus tie rods at 48 inches maximum along joints and intermediates. Tie rod sizes: ¼-inch diameter for 36-inch length or less, ⅜-inch diameter over 36 inches. Space at even divisions of duct width.

TABLE NO. 10-2-N—RECTANGULAR DUCT REINFORCEMENT

6″ W.G. STATIC POSITIVE	0.058 (16 GAGE)	0.047 (18 GAGE)	0.036 (20 GAGE)	0.030 (22 GAGE)	0.024 (24 GAGE)
DUCT DIMENSION	MINIMUM CLASS MAXIMUM SPACING				
8″ down	Not required	Not required	Not required	Not required	Not required
9″ to 10″	↓	↓	↓	A @ 5′	A @ 5′
11″ to 12″	↓	↓	A @ 10′	A @ 5′	A @ 5′
13″ to 14″	↓	↓	A @ 10′	A @ 8′	A @ 5′
15″ to 16″	↓	A @ 10′	B @ 10′	A @ 5′	A @ 5′
17″ to 18″	C @ 10′	C @ 10′	B @ 5′	B @ 5′	B @ 4′
19″ to 20″	C @ 10′	C @ 8′	B @ 5′	B @ 5′	B @ 4′
21″ to 22″	D @ 10′	C @ 8′	C @ 5′	C @ 5′	C @ 4′
23″ to 24″	D @ 10′	D @ 8′	C @ 5′	C @ 5′	C @ 3′
25″ to 26″	D @ 8′	D @ 5′	D @ 5′	C @ 4′	C @ 3′
27″ to 28″	E @ 8′	D @ 8′	D @ 5′	D @ 4′	C @ 3′
29″ to 30″	D @ 5′	D @ 8′	D @ 4′	D @ 4′	D @ 3′
31″ to 36″	F @ 5′	F @ 5′	E @ 4′	E @ 3′	E @ 2½′
37″ to 42″	G @ 5′	G @ 4′	F @ 3′	E @ 2½′	
43″ to 48″	H @ 4′	H @ 4′	G @ 2½′	G @ 2½′	
49″ to 54″	H @ 4′	H @ 3′	H @ 2½′	G @ 2′	
55″ to 60″	H @ 3′	H @ 3′	H @ 2½′	H @ 2′	
61″ to 72″	J @ 3′	J @ 2½′	I @ 2′		
73″ to 84″	L @ 2½′	K @ 2′			
85″ to 96″	L @ 2′	L @ 2′			
Over 96″		H @ 2½′*			

Notes:

1. Reinforcement class refers to transverse joint or intermediate members having stiffness and other characteristics indicated in tables.
2. Joint spacing is unrestricted.
3. Reinforcement is evaluated for each duct side separately. When required on four sides, corners shall be tied. When required on two sides, they shall be tied with rods or angles at the ends on 4-, 6- and 10-inch pressure classes.
4. The same gage of metal shall be used on all four sides of a cross section.
5. *Plus tie rods at 48 inches maximum along joints and intermediates. Tie rod sizes: ¼-inch diameter for 36-inch length or less, ⅜-inch diameter over 36 inches. Space at even divisions of duct width.

TABLE NO. 10-2-O—RECTANGULAR DUCT REINFORCEMENT

10″ W.G. STATIC POSITIVE	0.058 (16 GAGE)	0.047 (18 GAGE)	0.036 (20 GAGE)	0.030 (22 GAGE)	0.024 (24 GAGE)
DUCT DIMENSION	**MINIMUM CLASS**		**MAXIMUM SPACING**		
8″ down	Not required	Not required	Not required	Not required	Not required
9″ to 10″	↓	↓	A @ 5′	A @ 5′	A @ 4′
11″ to 12″	↓	A @ 8′	A @ 5′	A @ 5′	A @ 4′
13″ to 14″	B @ 8′	B @ 8′	A @ 5′	A @ 4′	A @ 3′
15″ to 16″	B @ 8′	B @ 5′	B @ 5′	B @ 4′	A @ 3′
17″ to 18″	C @ 8′	C @ 5′	C @ 5′	B @ 4′	B @ 3′
19″ to 20″	D @ 8′	C @ 5′	C @ 4′	B @ 3′	B @ 3′
21″ to 22″	C @ 5′	C @ 5′	C @ 4′	C @ 3′	C @ 3′
23″ to 24″	D @ 5′	D @ 5′	D @ 4′	C @ 3′	C @ 3′
25″ to 26″	D @ 5′	D @ 5′	D @ 4′	D @ 3′	C @ 2½′
27″ to 28″	E @ 5′	E @ 5′	D @ 4′	D @ 3′	D @ 2½′
29″ to 30″	E @ 5′	E @ 4′	D @ 3′	D @ 3′	D @ 2½′
31″ to 36″	F @ 5′	F @ 4′	F @ 3′	E @ 2½′	E @ 2′
37″ to 42″	H @ 4′	G @ 3′	G @ 2½′	F @ 2′	
43″ to 48″	H @ 3′	H @ 2½′	G @ 2′	G @ 2′	
49″ to 54″	I @ 3′	H @ 2½′	H @ 2′		
55″ to 60″	J @ 3′	I @ 2½′	I @ 2′		
61″ to 72″	K @ 2½′	K @ 2′			
73″ to 84″	H @ 2′				
85″ to 96″	H @ 2′*				
Over 96″	H @ 2′*				

Notes:

1. Reinforcement class refers to transverse joint or intermediate members having stiffness and other characteristics indicated in tables.
2. Joint spacing is unrestricted.
3. Reinforcement is evaluated for each duct side separately. When required on four sides, corners shall be tied. When required on two sides, they shall be tied with rods or angles at the ends on 4-, 6- and 10-inch pressure classes.
4. The same gage of metal shall be used on all four sides of a cross section.
5. *Plus tie rods at 48 inches maximum along joints and intermediates. Tie rod sizes: ¼-inch diameter for 36-inch length or less, ⅜-inch diameter over 36 inches. Space at even divisions of duct width.

TABLE NO. 10-2-P-1—RECTANGULAR ALUMINUM DUCT ADAPTED FROM 3″ W.G. OR LOWER STEEL CONSTRUCTION TABLES

Amend Tables Nos. 10-2-G, 10-2-H and 10-2-L by using equivalent thickness from this table.

Galv. Steel Thickness Inches (Gage)	0.016″ (28)	0.019″ (26)	0.024″ (24)	0.030″ (22)	0.036″ (20)	0.047″ (18)	0.058″ (16)
Min. Alum. equivalent*	.023	.027	.035	.043	.052	.068	.084
Commerical Size	.025	.032	.040	.050	.064	.071	.090
Aluminum weight 171.1 pounds per cubic foot.							

***Note:** The aluminum reference in the table is Alloy 3003-H14. If calculations are performed, the following allowable stresses shall be used: tension or compression, 10,000 psi; shear, 6,000 psi; bearing, 16,000 psi. Unstiffened flanges shall have stress reduced for the specified width-to-thickness ratio.

TABLE NO. 10-2-P-2—DIMENSION ADJUSTMENTS

Galvanized rigidity class	A	B	C	D	E	F	G	H	I	J	K	L
Aluminum dimension per galvanized class	C	D	E	F	H	H	I	K	**	**	**	**

**Calculate an $I_x = 3$ x that used for steel.

TABLE NO. 10-2-P-3—REINFORCEMENTS

STEEL ANGLE SIZE, (Inches)	CODE	EQUIVALENT ALUMINUM*** ANGLE SIZE, (Inches)	STEEL BAR	ALUMINUM BAR***
1 × 1 × 0.058″ (16 Ga.)	C	1 1/4 × 1 1/4 × 1/8	1 × 1/8	1 1/2 × 1/8 or 1 1/4 × 3/16
1 × 1 × 1/8	D	1 1/2 × 1 1/2 × 1/8	1 1/2 × 1/8	1 1/2 × 3/8 or 2 × 3/16
1 1/4 × 1 1/4 × 1/8	E	1 3/4 × 1 3/4 × 1/8		
1 1/2 × 1 1/2 × 1/8	F	2 × 2 × 3/16 or 2 1/2 × 2 1/2 × 1/8		
1 1/2 × 1 1/2 × 3/16	G	2 × 2 × 1/4 or 2 1/2 × 2 1/2 × 1/8		
2 × 2× 1/8	H	2 1/2 × 2 1/2 × 3/16		
2 × 2 × 3/16	I	2 1/2 × 2 1/2 × 5/16 or 3 × 3 × 1/4		
2 × 2 × 1/4	J	2 1/2 × 2 1/2 × 3/8 or 3 × 3 × 1/4		
2 1/2 × 2 1/2 × 3/16	K	3 × 3 × 3/8 or 3 1/2 × 3 1/2 × 1/4		

***Alloy 6061-T6 strength normally.

Notes for using Tables 10-2-P-1, P-2 and P-3:

1. For Tables Nos. 10-2-G, 10-2-H, and 10-2-L: Use equivalent thickness from Table No 10-2-P-1 for required thickness of aluminum stock.
2. For Tables Nos. 10-2-I and 10-2-K:
   2a. A connector not using angles or bar stock shall have its thickness increased per Table No. 10-2-P-1 and its dimensions increased per Table No. 10-P-2.
   2b. A connector using angles or bar stock shall have its aluminum thickness increased per Table No. 10-2-P-1 and shall use either aluminum stock or galvanized stock from Table No. 10-2-P-3.
3. Table No. 10-2-J: Galvanized steel members of dimensions given may be used or aluminum members having thickness and dimension conforming to Table No. 10-2-P-3 may be used. Other suitable aluminum shapes having a moment of inertia three times that of steel may be used.
4. Button-punch snaplock seams shall not be used in fabricating aluminum rectangular duct.

Tie Rod Installations

In Tables Nos. 10-2-G, H, L, M, N and O, duct sizes over 48 inches have a tie rod optional construction for positive pressures.

TABLE NO. 10-2-Q
INTERMEDIATE TIE RODS AT REINFORCEMENT
(Between Joints)

DUCT WIDTH	TABLE REINFORCEMENT GRADE	REINFORCEMENT GRADE FOR TIE ROD OPTION
49″ to 96″	G,H,I or J	11/2″ × 1/2″ × 1/8″ angle with tie rod at center
73″ to	K or L	11/2″ × 11/2″ × 3/16″ angle with tie rod at center
97″ up	H with tie rod	2″ × 2″ × 1/8″ angle with tie rod at 60″ maximum intervals

Tie Rods at Joints

The direct attachment of the tie rod by brazing or welding to a vertical leg of the joint is allowed for joints T-15, T-20, T-22 and T-23.

The attachment of a tie rod to an angle that reinforces a joint is allowed for joints T-4, T-8, T-9, T-15, T-16, T-19 and T-21. The angle shall meet the requirements for tie-rodded intermediate reinforcement.

The attachment of two tie rods or tie straps to the duct wall by welding or bolting within 1 inch of both sides of joints T-15, T-20, T-21 and T-23 is allowed.

Additional General Requirements

Ties shall be attached in such a manner that they will not loosen or detach with normal operating pressure fluctuations in the duct. When ties are to be welded to the duct wall the rod or strap shall have a 90 degree bend with 5/8-inch minimum extension beyond the bend. The extension of the rod shall be welded to the duct. The strap shall be welded to duct at the 90 degree bend.

Holes made in the duct wall for tie rod passage shall be the minimum size.

Tie rods shall be galvanized steel of 1/4-inch minimum diameter if 36-inch length or less and 3/8-inch minimum diameter for greater length.

Tie straps shall be 1-inch by 1/8-inch galvanized steel minimum and a smallest edge shall face the airflow direction.

Ties shall be spaced at even intervals of duct width not exceeding 60 inches.

The use of ties does not void the need to attach reinforcements to the duct wall: however, when ties occur outside of the duct as on two-side reinforcements at 4-inch w.g. and over, the attachment within 2 inches of the corner is not required.

When ties occur in two directions in the same vicinity, they shall either be prevented from contacting or shall be in permanent contact.

Ties may be used as components of the suspension system for ducts over 96-inch width, provided that the hanger load is directly transmitted to a trapeze or duct reinforcement member beneath the duct.

The construction of ducts of widths greater than 96 inches requires use of tie rods on Grade H joints and intermediates (2 inches × 2 inches × 1/8 inch) at intervals not exceeding 60 inches in the transverse direction. For 10″ w.g., 16 gage ducts with 2 feet reinforcement spacing is required; 18 gage duct is required at lower pressures with spacings of 2 feet at 6″ w.g.; 21/2 feet at 1″ to 4″ w.g. and 5 feet at 1/2″ w.g.

UNIFORM MECHANICAL CODE STANDARD NO. 10-3
TEST METHOD FOR FIRE AND SMOKE CHARACTERISTICS OF ELECTRICAL CABLE

Based on Standard No. 910, 1982, of Underwriters Laboratories Inc.

See Section 1002, Uniform Mechanical Code

Scope

Sec. 10.301. This is a test method for determining values of flame distance and smoke density for exposed electrical cables that are to be installed in concealed spaces above suspended ceilings used as air plenums without the cables being enclosed in raceways in those spaces. The purpose of this test method is to determine whether the flame-propagation and smoke-generating characteristics of these cables without raceways are in accordance with the provisions of Exception 6 to Uniform Mechanical Code Section 1002 (a).

Exclusions

Sec. 10.302. This test method does not cover the construction requirements for cables or their electrical and other performance requirements.

Fire-test Chamber

Sec. 10.303. The fire-test chamber shall consist of a horizontal duct having the shape and size shown in Figures Nos. 10-3-1, 10-3-2 and 10-3-3. The sides and base of the duct shall be lined with insulating masonry as illustrated in Figure No. 10-3-2 consisting of a row of A.P. Green G-26 refractory firebrick. The operation and calibration of this equipment is based on the use of A.P. Green G-26 refractories. One side shall be provided with a row of double-pane (inside pane mounted flush with inner wall—see Figure No. 10-3-3) pressure-tight (as described in Section 10.305) observation windows located so that the entire length of the specimens being tested can be observed from outside the fire-test chamber.

The ledges shall be fabricated of structural metal. Water-cooled structural-steel tubing is acceptable for this purpose.

To provide air turbulence for combustion, turbulence-inducing baffling shall be provided by positioning six A.P. Green G-26 refractory firebricks (long dimension vertical and 4.5-inch dimension parallel to wall) along the sidewalls of the chamber at distances of 7.0, 12.0 and 20.0, ± 0.5 feet on the window side and 4.5, 9.5 and 16.0, ± 0.5 feet on the opposite side.

The top shall consist of a removable metal-and-mineral-insulation composite unit whose insulation consists of nominal 2.0-inch-thick mineral-composition material. The top unit is shown in Figure No. 10-3-3 and shall completely cover the fire-test chamber. The mineral-composition material shall have physical characteristics comparable to the following:

Maximum effective temperature—1200°F.

Bulk density—12.5 ± 1.5 lbm/ft.^{3}

Thermal conductivity—0.50-0.71 Btu • inch per hour • square foot • °F. at 300-700°F.

The entire top-panel unit shall be protected with flat sections of high-density (nominally 110 lbm/ft.^{3}) 0.25-inch mineral-fiber/cement board maintained in unwarped and uncracked condition through continued replacement. While in place, the top panel shall be completely sealed against the leakage of air into the fire-test chamber during the test.

The ladder-type cable tray used to support the open-cable test specimens or the wiring-in-raceway test specimens is shown in Figures Nos. 10-3-2 and 10-3-3. The tray shall be fabricated from cold-rolled steel, 50,000 psi minimum tensile strength. The solid-bar-stock side rails shall be as shown in Section S-S in Figure No. 10-3-3. The C-shaped-channel rungs shall be as shown in Section Q-Q in Figure No. 10-3-3. Each rung shall be 11.25 inches long. The rungs shall be welded to the side rails 9.00 inches on centers along the tray length. The tray may consist of several sections having a total assembled length of 23.9 feet and shall be supported with 16 supports equally spaced along the length of the tray. The supports shall be fabricated from bar steel.

One end of the test chamber, designated as the "fire end," shall be provided with two gas burners delivering flames upward that engulf the cross section of the test specimens midway between two rungs of the cable tray. The burners shall be positioned transversely to each side of the center line of the furnace so that the flame is evenly distributed over the width of the specimens. See Figure No. 10-3-2.

The controls used to maintain a constant flow of gas to the burners shall consist of a pressure regulator, a gas meter calibrated to read in increments of not more than 0.1 ft.^{3}, a gauge to indicate gas pressure in inches of water, a quick-acting gas-shutoff valve, a gas-metering valve, and an orifice plate in combination with a manometer to assist in maintaining uniform gas-flow conditions. An air intake fitted with a vertically sliding shutter extending the entire width of the test chamber shall be provided at the fire end. The shutter is to be positioned to provide an air-inlet port as shown in Figure No. 10-3-1.

The other end of the test chamber, designated as the "vent end," shall be fitted with a rectangular-to-round transition piece, which shall be fitted to a round flue pipe. The movement of air shall be by induced draft. The draft-inducing system shall have a total draft capacity of at least 0.15-inch water column with the specimens in place, with the shutter at the fire end open to its normal position, and with the damper in the wide-open position. A draft-gauge manometer to indicate static pressure shall be connected in the vent pipe upstream of the damper and the photoelectric-cell opening.

The damper shall be installed in the vent pipe downstream of the smoke-indicating attachment described in this section.

An automatic draft-regulator controller may be mounted in the vent pipe downstream of the manual damper. Other manual, automatic or special draft-regulation devices may be incorporated to maintain airflow control throughout each test run.

The room in which the test chamber is located shall have provision for a free inflow of air to maintain the room at atmospheric pressure throughout each test run.

A light source shall be mounted on a horizontal section of the vent pipe at a point at which it is preceded by a straight run of round pipe at least 12 diameters or 16 feet from the vent end of the rectangular-to-round transition section, and it is not affected by flame from the test chamber. The light beam shall be directed upward along the vertical axis of the vent pipe. The vent pipe shall be insulated with high-temperature mineral-composition material from the vent end of the chamber to the photometer location. A photoelectric cell having an output directly proportional to the amount of light received shall be mounted over the light source with an overall light-to-cell path length of 36.00 ± 2.00 inches, 16 inches of which are taken up by the smoke in the vent-pipe interior as shown in Section C-C of Figure No. 10-3-1. The cell shall be connected to recording devices for indicating changes in the attenuation of incident light by passing smoke, by particulate matter and by other effluents.

The output of the photoelectric cell shall be connected to a recording device that processes the signal into a continuous record of smoke obscuration.

$$\text{Optical density} = \log_{10}\frac{T_o}{T}$$

WHERE:

T_o = the initial light transmission (without smoke).

T = the light transmission during the test. T varies with the amount of smoke.

A No. 18 AWG thermocouple (nominal wire cross section of 1620 CM) with 0.375 ± 0.125 inch of the junction exposed in the fire-chamber air shall be inserted through the floor of the test chamber so that the tip is 1.000 ± 0.031 inch below the top surface of the gasketing tape and within 1.0 foot of the vent end of the test chamber at the center of the width of the chamber.

A No. 18 AWG thermocouple (nominal wire cross section of 1620 CM) embedded 0.125 inch below the floor surface of the test chamber shall be mounted in refractory or portland cement at distances of 13.5 and 24.0 feet from the fire end of the test chamber.

Test Specimens

Sec. 10.304. Cable specimens in 24.0-foot lengths shall be installed in a single layer across the bottom of the cable tray. The specimens shall be laid into the tray in parallel, straight rows without any space between adjacent specimens other than that needed for the cable fasteners described in the following paragraph. The number of cable specimens shall equal the measured inside width of the rack divided by the cable diameter as determined using a diameter tape or the equivalent, with the result of the division rounded off to the nearest lower whole number of specimens that fit, considering the presence of cable fasteners.

Bare copper tie wires not larger than No. 18 AWG (nominal wire cross section of 1620 CM) may be used to fasten cable specimens to the rungs of the cable tray wherever a tie is necessary to keep a cable in contact with the rung, straight and parallel with all of the other cable specimens and to minimize movement during the test. A tie shall not be used in any manner that alters the ability of the cable to transmit gases and/or vapors longitudinally through the core of the cable.

Properties applicable to identification of the cable specimens shall be determined and recorded.

Calibration of Test Equipment

Sec. 10.305. One 0.250-inch mineral-fiber/cement board shall be placed on the ledge of the furnace chamber. The removable top of the test chamber shall be placed in position.

With the board in position and with the removable top in place, the draft shall be established to produce a 0.15-inch water-column reading on the draft manometer with the fire-end shutter open 3.000 ± 0.062 inches and with the manual damper in the wide-open position. Then, the fire-end shutter shall be closed and sealed. The manometer reading shall increase to at least a 0.375-inch water column, indicating that no excessive air leakage exists.

In addition, a supplemental leakage test shall be conducted periodically by activating a smoke bomb in the fire chamber while the fire shutter and exhaust duct beyond the differential manometer tube are sealed. The bomb shall be ignited and the chamber pressurized to 0.375 ± 0.150-inch water column. All points of leakage observed in the form of escaping smoke particles shall be sealed.

A draft reading shall be established within the range of a 0.055-0.085-inch water column. The required draft-gauge reading shall be maintained by regulating the manual damper. The air velocity at each of seven points, each located 1.0 foot from the vent end shall be recorded. These points shall be determined by dividing the width of the tunnel into seven equal sections and recording the velocity at the geometric center of each section. The average velocity shall be 240 ± 5.0 feet per minute.

The air supply shall be maintained at 70.0 ± 5.0°F. and the relative humidity shall be kept at 35-40 percent.

The test fire which produces approximately 300,000 Btu per hour shall be fueled with bottled methane gas of uniform quality and with a heating value of approximately 1000 Btu per cubic foot. The gas supply shall be initially adjusted to approximately 5000 Btu per minute. The gas pressure, the pressure differential across the orifice plate, and the volume of gas used shall be recorded in each test. A length of coiled copper tubing shall be inserted into the gas line between the supply and the metering connection to compensate for possible errors in the indicated flow because of reductions in the gas temperature associated with the pressure drop and expansion across the regulator, or other applicable means of correction may be used. With the draft and the gas supplies adjusted, the test flames shall extend downstream to a distance of 4.5 feet over the specimens, with negligible upstream coverage.

The test chamber shall be preheated with the mineral-fiber/cement board and the removable top in place and with the fuel supply adjusted to the required flow. The preheating shall be continued until the temperature indicated by the floor thermocouple at 24.0 feet reaches 150 ± 5°F. During the preheat test, the temperatures indicated by the thermocouple at the vent end of the test chamber shall be recorded at 15-second intervals and shall be compared to the preheat temperatures taken at the same intervals from the representative curve of temperature as a function of time shown in Figure No. 10-3-4. The preheating is for the purpose of establishing the conditions that exist following successive tests and to indicate the control of the heat input into the test chamber. If appreciable variation from the temperatures shown in the representative preheat curve occurs because of variations in the characteristics of the gas used, adjustments in the fuel supply shall be made prior to proceeding with the red-oak calibration tests.

The furnace shall cool after each test. As soon as the floor thermocouple at 14 feet shows a temperature of 105 ± 5°F., the next set of specimens shall be placed in position for test.

With the test equipment adjusted and conditioned as described in this section, a test or series of tests shall be made using nominally $^{23}/_{32}$-inch Select grade red-oak flooring in place of the mineral-fiber/cement board. Prior to the testing, the wood shall be conditioned to a moisture content of 6-8 percent as determined by the 221°F. oven-dry method in accordance with nationally recognized standards. Observations shall be made continually and the time shall be recorded when the flame reaches the end of the specimen—that is, 19.5 feet from the end of the ignition fire. The end of the ignition fire shall be considered as being 4.5 feet from the burners. The flame shall reach the end point in 5.5 minutes ± 15 seconds. The flame shall be judged to have reached the end point when the vent-end thermocouple registers a temperature of 980°F. The temperature measured by the thermocouple near the vent end shall be recorded at least every 30 seconds. The photoelectric-cell output shall be recorded immediately prior to the test and at least every 15 seconds during the test. The test shall be run for 10 minutes.

The temperature and change in photoelectric-cell readings shall be plotted separately on coordinate paper. Figures Nos. 10-3-5 to 10-3-7 are representative curves for the flame spread on red oak, fuel contribution of red oak, and the optical density from red oak.

Following the 10-minute calibration tests for red oak, a similar test or tests shall be conducted on specimens of 0.250-inch mineral-fiber/cement board. The temperature readings shall be plotted separately on coordinate paper. Figure No. 10-3-8 is a representative curve for the fuel contribution of mineral-fiber/cement board.

Test Procedure

Sec. 10.306 The cable tray and supports shall be placed in the test chamber with the end 1.0 inch downstream from the center line of the burners.

The furnace shall be preheated and cooled as described in Section 10.305.

The specimens shall be installed and the removable test-chamber top placed in position on top of the furnace side ledge.

The test equipment shall be adjusted and conditioned as described in Section 10.305 with the open-cable test specimens in place.

The test gas flame shall be ignited. The distance and time of maximum flame front shall be observed and recorded. The test shall be continued for 20 minutes.

The photoelectric-cell output shall be recorded immediately prior to the test and continuously during the test.

The gas pressure, the pressure differential across the orifice plate, and the volume of gas used shall be recorded for the duration of the test.

After the gas supply to the ignition flame is shut off, smoldering and other conditions within the furnace shall be observed and recorded, and the specimens removed for examination.

Report

Sec. 10.307. The report shall include all of the following for each test:

1. A detailed description of the open-cable specimens tested.
2. The number of lengths used as specimens for the test.
3. The graph of flame distance versus time for the duration of the test.
4. The values of the peak optical density and average optical density.
5. The graph of the optical density of the smoke generated during the test versus time for the duration of the test. Optical density may be obtained by computer-assisted computation of the logarithm to the base 10 of the light-transmission data.
6. Observations of the condition of the test specimens after completion of the test.
7. The weight of nonmetallic components normalized to a figure based on 1000 feet of tray length. For example, if the weight of a length of 1 foot of the specimen cable minus the metallic-component weight, is 0.016 pound and there are 15 cables in the tray, the normalized value is 0.016 × 15 × 1000 = 240 pounds per 1000 feet of tray.

Acceptance Criteria

Sec. 10.308. To be acceptable for installation exposed in concealed space above suspended ceilings used as air plenums electrical cable shall:

1. Exhibit a flame travel not greater than 5 feet, and
2. Produce smoke having an average optical density not greater than 0.15 and a peak optical density not greater than 0.5 when tested as outlined in this standard.

FIGURE NO. 10-3-1
DETAILS OF FIRE-TEST CHAMBER
See Figure No. 10-3-2 for Section B-B.

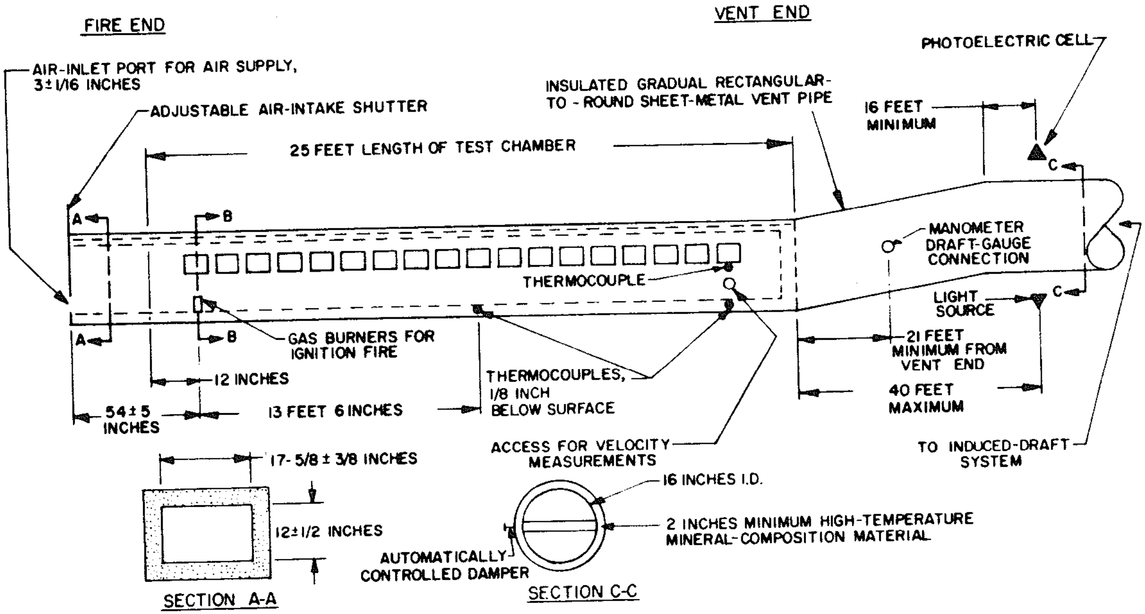

FIRE END
VENT END
AIR-INLET PORT FOR AIR SUPPLY, 3±1/16 INCHES
ADJUSTABLE AIR-INTAKE SHUTTER
25 FEET LENGTH OF TEST CHAMBER
INSULATED GRADUAL RECTANGULAR-TO-ROUND SHEET-METAL VENT PIPE
16 FEET MINIMUM
PHOTOELECTRIC CELL
A
B
C
MANOMETER DRAFT-GAUGE CONNECTION
THERMOCOUPLE
LIGHT SOURCE
GAS BURNERS FOR IGNITION FIRE
12 INCHES
THERMOCOUPLES, 1/8 INCH BELOW SURFACE
21 FEET MINIMUM FROM VENT END
40 FEET MAXIMUM
54±5 INCHES
13 FEET 6 INCHES
ACCESS FOR VELOCITY MEASUREMENTS
TO INDUCED-DRAFT SYSTEM
17-5/8 ± 3/8 INCHES
12±1/2 INCHES
16 INCHES I.D.
2 INCHES MINIMUM HIGH-TEMPERATURE MINERAL-COMPOSITION MATERIAL
AUTOMATICALLY CONTROLLED DAMPER
SECTION A-A
SECTION C-C

FIGURE NO. 10-3-2
SECTION B-B

See Figure No. 10-3-3 for details of the cable tray and supports.

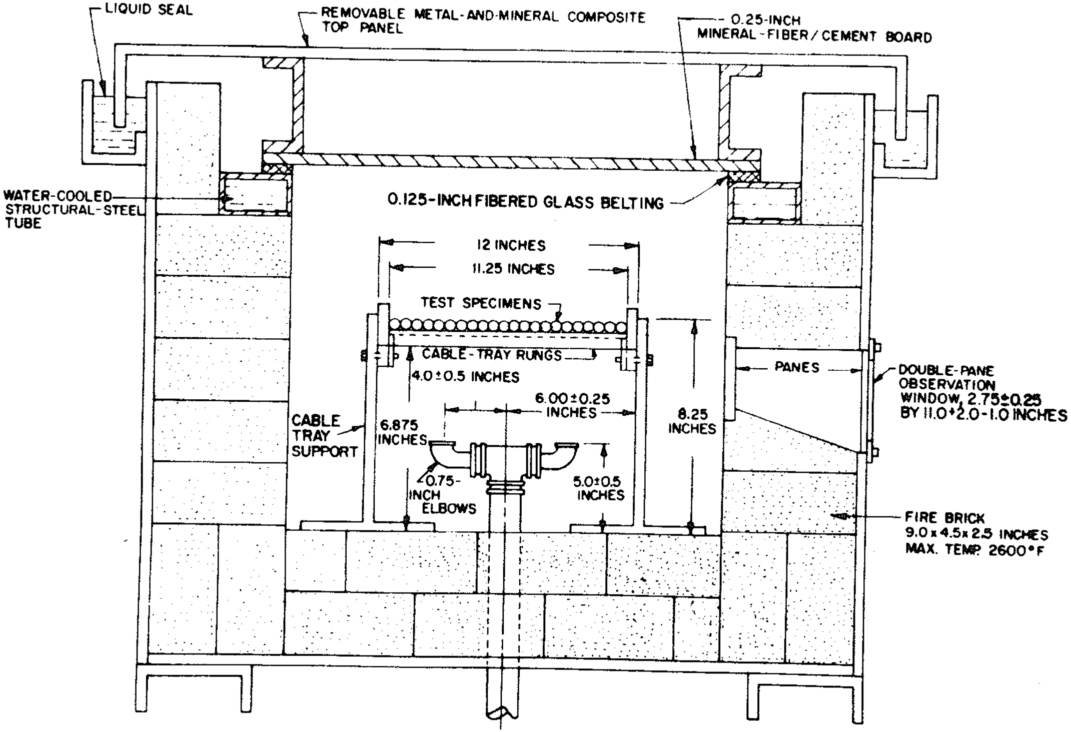

LIQUID SEAL
REMOVABLE METAL-AND-MINERAL COMPOSITE TOP PANEL
0.25-INCH MINERAL-FIBER/CEMENT BOARD
WATER-COOLED STRUCTURAL-STEEL TUBE
0.125-INCH FIBERED GLASS BELTING
12 INCHES
11.25 INCHES
TEST SPECIMENS
CABLE-TRAY RUNGS
4.0±0.5 INCHES
6.00±0.25 INCHES
8.25 INCHES
PANES
DOUBLE-PANE OBSERVATION WINDOW, 2.75±0.25 BY 11.0+2.0-1.0 INCHES
CABLE TRAY SUPPORT
6.875 INCHES
0.75-INCH ELBOWS
5.0±0.5 INCHES
FIRE BRICK 9.0 x 4.5 x 2.5 INCHES MAX. TEMP. 2600°F

FIGURE NO. 10-3-3
DETAILS OF STEEL CABLE TRAY AND SUPPORTS

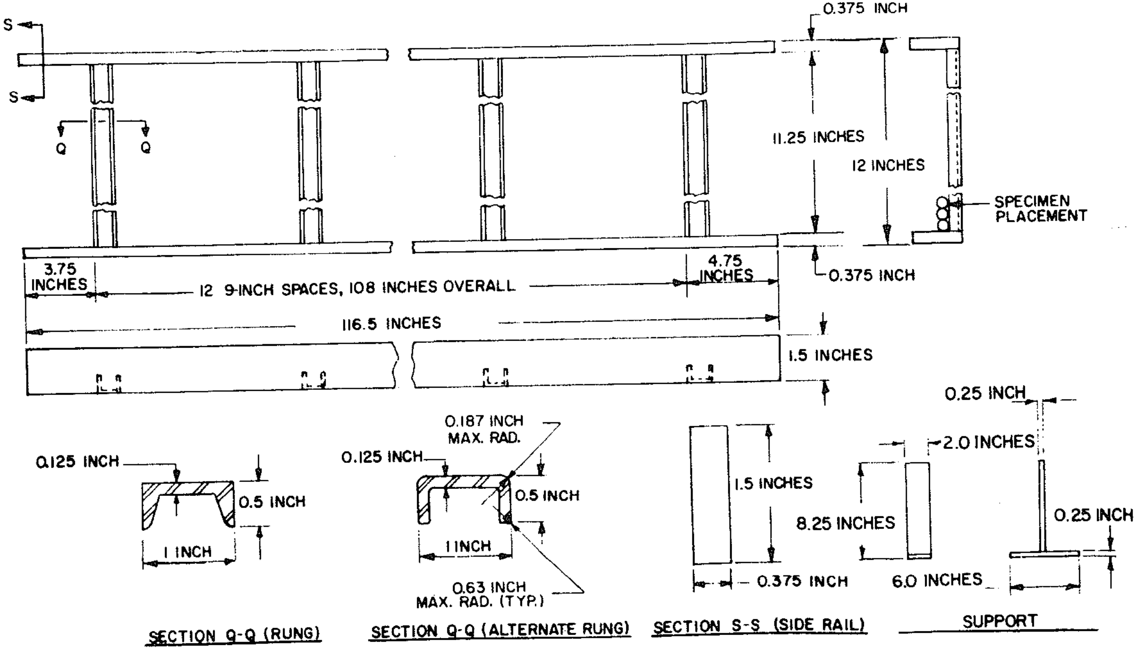


FIGURE NO. 10-3-4
REPRESENTATIVE PREHEAT CURVE

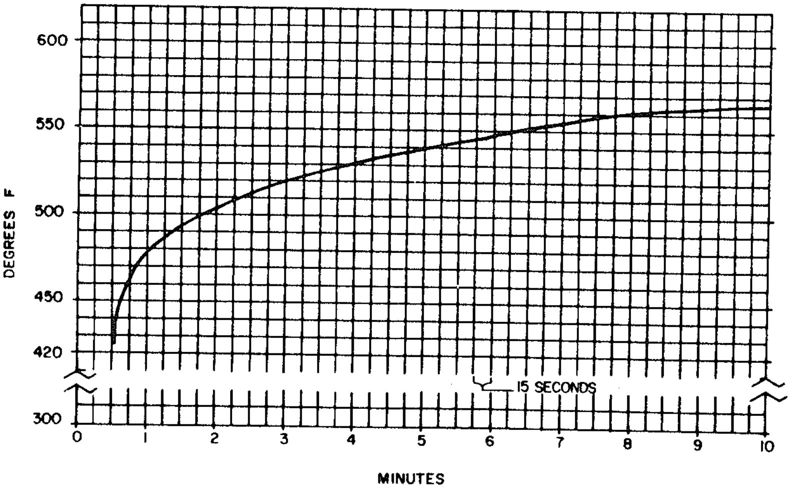


FIGURE NO. 10-3-5
REPRESENTATIVE CURVE OF FLAME SPREAD ON RED OAK

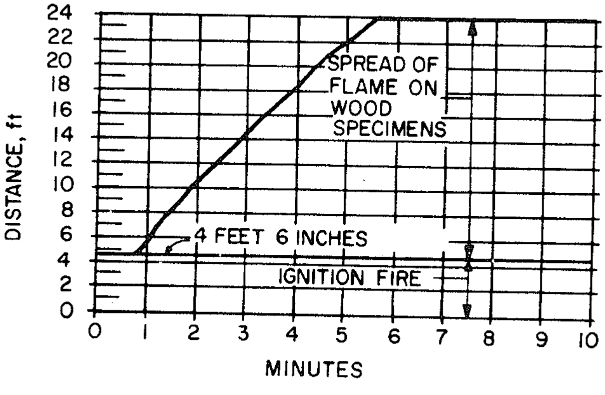


FIGURE NO. 10-3-6
REPRESENTATIVE CURVE OF FUEL CONTRIBUTION OF RED OAK

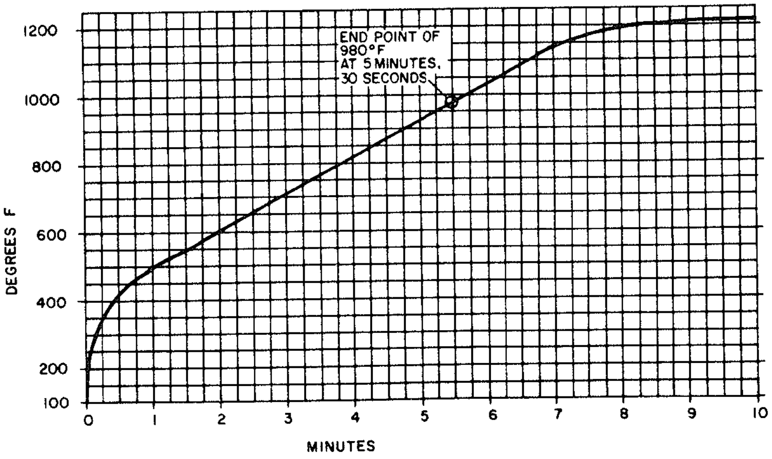


FIGURE NO. 10-3-7
REPRESENTATIVE CURVE OF OPTICAL DENSITY FROM RED OAK

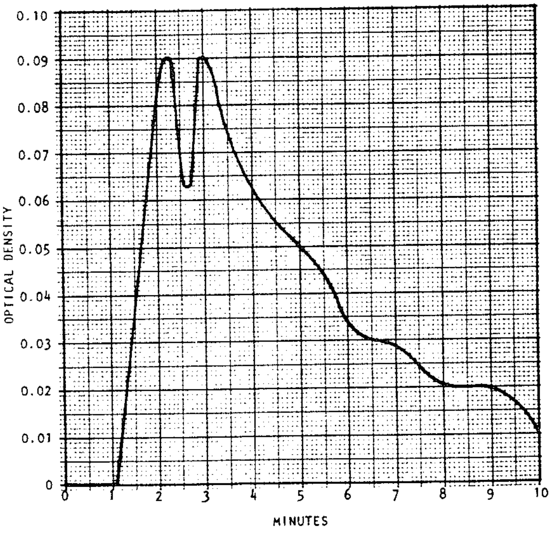
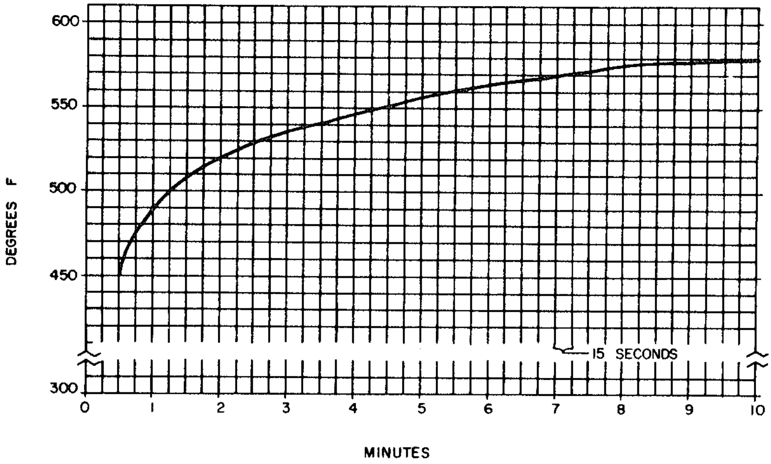


FIGURE NO. 10-3-8
REPRESENTATIVE CURVE OF FUEL CONTRIBUTION OF MINERAL-FIBER/CEMENT BOARD



UNIFORM MECHANICAL CODE STANDARD NO. 10-4

HEAT RESPONSIVE LINKS FOR FIRE PROTECTION SERVICE

Based on Standard No. 33, 1982, of Underwriters Laboratories Inc.

See Section 1006, Uniform Mechanical Code, and Section 4306, Uniform Building Code

Scope

Sec. 10.401. These requirements cover heat-responsive links used for fire-protection service.

Heat-responsive links are categorized by temperature rating, type of coating or plating, minimum and maximum design load, and other factors which may have a bearing on their intended use.

Glossary

Sec. 10.402. For the purpose of this standard, the following definitions apply:

BIMETALLIC TYPE is two different metals mechanically fastened together. Each metal has different expansion characteristics, and this device is intended to be reset.

GLASS BULB TYPE is a liquid-filled glass bulb which fractures when exposed to sufficient heat.

SOLDERED TYPE is two or more metallic parts bonded together by solder, intended to be in tension when subjected to a load.

STRUT TYPE is a mechanical arrangement of parts which apply a compressive load to a solder capsule.

Temperature Ratings

Sec. 10.403. Heat-responsive links in their various ratings shall be designed for service where the maximum ambient air temperatures at the point of installation do not exceed those specified for the maximum temperature in Table No. 10-4-1.

Heat-responsive links shall have operating temperatures as specified in Table No. 10-4-1.

Coatings and Platings

Sec. 10.404. The operation characteristics of a heat-responsive link shall not be impaired by the application of any factory-applied coating or plating when tested in accordance with these requirements.

A corrosion-resistant coating or plating shall be uniformly applied.

A wax coating shall not be brittle when new nor become brittle with age.

A wax coating shall not crack, flake, slip or flow when tested at the maximum temperature at which the fusible link may be installed. See the High Temperature—Coated Test, Section 10.409.

Strength of Heat-responsive Element Assembly and Fusible-link Assembly Tests

Sec. 10.405. (a) **General.** A product shall comply with the requirements specified in either (1) Section 10.405 (b) 1 or Sections 10.405 (b) 2 through 6 for fusible-alloy types or (2) Sections 10.405 (c) 1 and 2 for frangible-bulb types.

(b) **Fusible-link Assemblies.** A fusible-link assembly shall support a load equal to five times the maximum design load for at least 150 hours.

1. At least ten sample fusible-link assemblies of the lowest ordinary degree temperature rating shall be loaded to five times the manufacturer's maximum design load for 150 hours at an ambient temperature of 70 ± 5°F. All ten samples shall comply with the requirements of Section 10.404.
2. As an alternative to the requirements specified in Subsections 10.405 (a) and 10.405 (b) 1, a fusible-link assembly shall support a load equal to five times the maximum design load for one minute when tested as specified in Section 10.405 (b) 3. In addition, the heat-responsive element assembly shall comply with the requirements specified in either Subsections (b) 4 through (b) 6 (fusible-alloy types) or Subsections (c) 1 and (c) 2 (frangible-bulb types).
3. At least ten sample fusible-link assemblies of the lowest ordinary degree temperature rating shall be loaded to five times the manufacturer's maximum design load for one minute at an ambient temperature of 70 ± 5°F. One attachment end of each sample shall be connected to the test-supporting apparatus. The test load shall be applied to the other attachment end in the intended direction. All ten samples shall comply with the requirements specified in Subsection (b) 2.
4. A fusible-alloy-type heat-responsive element assembly in the lowest ordinary degree temperature rating shall demonstrate the ability to sustain the maximum design load when tested in accordance with Subsections (b) 5 and (b) 6.
5. Compliance with the requirements specified in Subsection (b) 4 shall be determined by subjecting sample fusible-alloy-type heat-responsive element assemblies to loads in excess of the maximum design load. A minimum of ten samples shall be loaded at various values as required, up to five times the design load, to derive a least-square, full-logarithmic regression curve of load as a function of time, from which the loads at one hour and at 1000 hours are to be determined. The maximum design load shall then be as follows:

$$L_b \leqslant \frac{L_m^2}{0.98L_o}$$

WHERE :

L_m = Load at 1000 hours.

L_o = Load at one hour.

L_d = Maximum design load.

6. The test samples shall be loaded at a conditioned temperature of 70 ± 5°F.

(c) **Frangible-bulb Types.** 1. For a frangible-bulb-type heat-responsive element assembly, the lower tolerance limit for bulb strength, based on calculations with a degree of confidence of 0.99 for 99 percent of samples, shall exceed twice the upper tolerance limit for the load applied to the bulb at maximum design load, based on calculations with the same degree of precision. Calculations are to be based on the Normal or Gaussian Distribution except where another distribution can be shown to be more applicable due to manufacturing or design factors. The bulb strength shall be measured by applying a steadily increasing load, using a compression testing machine, until the bulb breaks or fractures. This test shall be conducted with the bulb mounted in the seating parts used in the assembly and the load applied at a rate not exceeding 55 pounds-force per second. Bulb seatings may be reinforced circumferentially in a manner not interfering with the bulb breakage. A minimum of 15 samples of each temperature rating and each bulb type shall be tested.

2. A frangible-bulb-type heat-responsive element assembly shall withstand the thermal shock of rapid temperature changes having a range from 20°F. less than its rated operating temperature to 50°F. At least five sample bulbs shall be conditioned for 5 minutes in a liquid bath at 20°F. less than its rated operating temperature. The samples then shall be removed and immediately submerged in another liquid bath at 50°F. There shall be no breakage or fracture of the glass bulb.

Operating Temperature (Bath) Test

Sec. 10.406. (a) **General.** A group of ten heat-responsive links of the same type and marked temperature rating shall, when bath tested, operate within a range having a maximum temperature not in excess of 10°F. or 107 percent of the minimum temperature of the range, whichever is greater. For the purpose of this determination, the marked temperature rating is to be included as one of the ranged values, making a total of 11 values in the range. When tested, each heat-responsive link shall operate with a positive action. Table No. 10-4-1 defines temperature ratings.

(b) **Sample Size.** Not less than ten heat-responsive links of both coated and uncoated types of each temperature rating shall be subjected to this test. All ten samples shall comply with the requirements of Subsection (a).

(c) **Load Applied.** The heat-responsive links shall be placed in an upright position under a load equal to the manufacturer's minimum design load but not less than 1 pound-force, and completely immersed in the water or oil bath. The vessel shall be provided with a source for heating the liquid at the prescribed rate and with means to agitate the liquid and measure the temperature of the liquid bath.

(d) **Bath Fluid.** Water shall be used in bath tests of heat-responsive links which have operating temperature ratings of 175°F. or lower. Samples having operating temperature ratings of 176 ± 575°F. shall be bath tested in an oil having a flash point exceeding the test temperature.

(e) **Agitation.** An agitator shall be used as an aid in obtaining uniformity in temperature of the bath liquid.

(f) **Temperature Measurement.** A laboratory mercury thermometer calibrated in accordance with nationally recognized standards shall be used to determine temperatures of the liquids used in bath tests. The bulb of a thermometer shall be held level with the fusible link by a support member.

(g) **Procedure.** The temperature of the bath liquid shall be raised until the liquid is within 20°F. of the temperature rating of the device, 30°F. for 325°F. and higher temperature ratings. The rate of temperature rise then shall be controlled at a rate not exceeding 1°F. per minute until operation or until a temperature 20°F. above the rated temperature is reached. The temperature of the liquid and the time of operation, as each heat-responsive link operates, shall be recorded.

Operation—Air Oven Test

Sec. 10.407. (a) **General.** Heat-responsive links with temperature ratings of 375°F. or lower shall operate with sharp, positive action under a test load equal to the manufacturer's minimum design load, but not less than 1 pound, with complete release of all operating parts when exposed to air within the temperature and time limits specified in Table No. 10-4-2.

(b) **Acceptance Criteria.** The operating temperatures of each of a similarly marked group of a given model and type of heat-responsive link shall, when air-oven tested, be within a range having maximum and minimum values within 20°F. for any individual test.

(c) **Sample Size.** Ten heat-responsive links of each of the following types are to be subjected to the air oven test, as follows, and all shall comply with the requirements of Subsection (b). All samples of heat-responsive links with temperature ratings of 375°F. or lower shall comply with the requirements of Subsection (a).

1. Uncoated of each temperature rating.
2. Coated of each temperature rating.
3. Plated of each temperature rating.

(d) **Test Oven Performance.** An oven test is to provide a means for subjecting samples to a rapidly rising air-temperature environment where the temperature rise follows a prescribed time-temperature relationship; where the velocity and path of the airstream are controlled and are uniform in the vicinity of the sample; and where other factors influencing heat transfer, such as radiant walls, are maintained uniform in their effects.

(e) **Time-Temperature Curves.** The time-temperature relationships, as specified by the curves illustrated in Figure No. 10-4-1, are indicative of the curves obtainable by the test method employed using test ovens.

(f) **Oven Construction.** The ovens which are used for the tests specified in Subsection (e) shall be made of stainless steel and provided with a water-circulating jacket. The body of each oven shall be cylindrical in shape with an internal diameter of 10 inches, an external diameter of 12 inches, and a height of 18 inches. Each oven shall be fitted with a movable lid which is 15 1/4 inches square on the bottom. The front of the lid shall be inclined approximately 75 degrees from the horizontal and have a heat-resistant glass window, approximately 13 1/4 by 4 3/4 inches. The natural gas fuel burners shall be controlled automatically, as specified in Subsection (h), and located at the bottom of the oven which is open to allow air intake. Air shall be continuously released from the lid of the oven through a centrally located 3-inch-diameter hole. A 4-inch-diameter baffle shall be located 1 inch above the air outlet hole to limit the air flow. The thermocouple used to record the temperature of the oven shall be made from No. 20 AWG wires, one chromel and one alumel, compacted with magnesium oxide within a 1/16-inch outside diameter stainless-steel sheath. The thermocouple shall be located centrally in the oven between the four spuds at a point approximately 1 1/2 inches above the base of the spuds. A centrally located stainless sheet steel drop shield shall be suspended below the four spuds. The shield shall be fabricated from two cones, one 3 inches high and another 7 inches high, welded together at their 5 1/2-inch-diameter base. The shield shall be placed in the oven with the apex of the 3-inch-high cone on top.

(g) **Loading Oven.** The heat-responsive links shall be placed in the oven under the minimum design load, but not less than 1 pound. Starting from a prescribed ambient situation in the oven, the temperature of the oven shall be increased in the manner specified by the applicable time-temperature curve illustrated in Figure No. 10-4-1.

(h) **Oven Temperature Controls.** The automatic time-temperature relationship shall be accomplished using a cam program controller having cams cut to provide the time-temperature rise specified in the curves in Figure No. 10-4-1. During each test the controller shall compare the temperature as measured by the thermocouple in the oven with the temperature called for by the controller cam follower and, when necessary, shall change the amount of gas to the burners by means of a modulated gas valve to bring the temperature recorded into agreement with the temperature called for by the cam program. This temperature comparison shall be made with each 1 2/3 °F. rise of the cam follower. The temperature recorded shall have a calibrated accuracy of ± 2°F. of the temperature at the air oven measuring thermocouple.

(i) **Sample Position.** In general, the samples being tested shall be placed in the oven in a vertical position. The samples shall be located in a symmetrical relationship with respect to the center vertical axis of the oven. Starting from the prescribed ambient situation in the oven, the temperature of the oven shall be increased in the manner prescribed by the time-temperature curve applicable to the test.

(j) **Coating Performance.** Coatings shall melt and run off or otherwise be dissipated from the surfaces of operating parts at or below the operating temperature of the sample under test so as not to impair operation.

(k) **Observations.** Observations are to be made and recorded of the time and temperature at which each sample operates and the manner in which the release of parts is accomplished.

High Temperature—Uncoated Test

Sec. 10.408. (a) **General.** An uncoated heat-responsive link subjected to the maximum design load shall withstand, for 90 days without evidence of weakness or failure, an exposure to a high-ambient temperature as specified in Table No. 10-4-3, or 20°F. below the rated operating temperature of the samples (whichever is the lower temperature), but in any case the test temperature shall be not lower than 120°F. for 135 to 140°F. or 110°F. for 125 to 130°F. links. After the exposure, each heat-responsive link with a temperature rating less than 375°F. shall be subjected to the Operation—Air Oven Test, Section 10.407. Heat-responsive links with a temperature rating over 375°F. shall be subjected to the Operating Temperature (Bath) Test, Section 10.406.

(b) **Oven and Sample.** An automatically controlled, circulating-type, constant-temperature oven is to be used for this test. Five previously untested heat-responsive links of each operating temperature shall be placed in an oven at the specified temperature and under the maximum design load.

(c) **Test Procedure.** Each sample shall be removed from the test oven at seven-day intervals for two to four hours and, after cooling to room temperature, shall be examined for evidence of weakness or failure in any of the parts. Each sample shall comply with the requirements of Subsection (a).

High Temperature—Coated Test

Sec. 10.409. (a) **General.** A coated heat-responsive link shall withstand, for 90 days without evidence of weakness or failure, an exposure to a maximum ambient temperature as specified in Table No. 10-4-1, or 20°F. below the rated operating temperature of the samples (whichever is the lower temperature), but in any case links having temperature ratings of 135 to 170°F. shall be tested at 120 ± 2°F., and links having temperature ratings of 125 to 130°F. shall be tested at 110 ± 2°F. The links shall be subjected to the maximum design load during this test. After the exposure, each heat-responsive link with a temperature rating less than 375°F. shall be subjected to the Operation—Air Oven Test, Section 10.407. Heat-responsive links with a temperature rating over 375°F. shall be subjected to the Operating Temperature (Bath) Test, Section 10.406.

(b) **Oven and Sample.** An automatically controlled, circulating-type, constant-temperature oven shall be used for this test. Five previously untested heat-responsive links with each type of coating shall be placed in the oven, the air of which shall be maintained constantly at the specified temperatures. Each sample shall be removed from the test oven at seven-day intervals and allowed to cool for two to four hours. After this cooling time, the sample shall be examined for evidence of weakness or failure in any of the parts. Each sample shall comply with the requirements of Subsection (a).

10-Day Corrosion Test

Sec. 10.410. A heat-responsive link shall withstand an exposure to salt spray, hydrogen sulfide and sulfur dioxide-carbon dioxide atmospheres as specified in Subsections 10.411 (b) through (f) for 10 days each. After the exposures, each sample having a temperature rating less than 375°F. shall be operable when subjected to the Operation—Air Oven Test, Section 10.407, and the average temperature of the operation shall not show an increase in excess of 10 percent when compared to the average temperature of samples not subjected to this 10-

Day Corrosion Test and no individual sample shall exceed the operation temperature limits of the Operation—Air Oven Test, Section 10.407. Heat-responsive links with a temperature rating over 375°F. shall be subjected to the Operating Temperature (Bath) Test, Section 10.406, and the average temperature of operation shall not increase in excess of 10 percent when compared to the average temperature of samples not subjected to the corrosion test.

30-Day Corrosion Test

Sec. 10.411. (a) **General.** A heat-responsive link intended for use in corrosive atmospheres shall withstand an exposure to salt spray, hydrogen sulfide and sulfur dioxide-carbon dioxide atmospheres as specified in Subsections (b) through (f) for 30 days. After the exposure, each test sample having a temperature rating less then 375°F. shall be operable when subjected to the Operation—Air Oven Test, Section 10.407, and the average temperature of operation of the test samples shall not increase in excess of 10 percent when compared to the average temperature of samples not subjected to the 30-Day Corrosion Test, and no individual sample shall exceed the operation temperature limits of the Operation—Air Oven Test, Section 10.407. Heat-responsive links with a temperature rating over 375°F. shall be subjected to the Operating Temperature (Bath) Test, Section 10.406, and the average temperature of operation shall not increase in excess of 10 percent when compared to the average temperature of samples not subjected to the corrosion test.

(b) **Sample Selection.** Three groups, each consisting of five sample heat-responsive links are to be assembled. One group is to be exposed to 20 percent salt spray, the second to hydrogen sulfide and the third to sulfur dioxide-carbon dioxide.

(c) **Follow-on Testing.** Not more than five days nor less than one day after the exposure period, each sample heat-responsive link shall be subjected [see Subsection (a)], as applicable, to the Operation—Air Oven Test, Section 10.407, or the Operating Temperature (Bath) Test, Section 10.406, for determination of its operating temperature.

(d) **Twenty Percent Salt Spray.** The test samples shall be supported vertically and exposed to salt spray (fog). The apparatus used for salt-spray exposure shall consist of a fog chamber, 48- by 30- by 36-inch inside dimensions, having a salt-solution reservoir, a supply of conditioned compressed air, a dispersing tower for producing a salt fog, sample supports, provision for heating the chamber and necessary means of control. The dispersion tower shall be located in the center of the chamber and is to be supplied with salt solution and with warmed, humidified air at a pressure of 17 to 19 psig to disperse the salt solution in the form of a fine mist or fog throughout the interior of the chamber. The temperature within the chamber shall be maintained at 95 plus 2 minus 3°F. Condensate accumulation on the cover of the chamber shall not be permitted to drop onto the test samples, and drops of the solution which fall from the samples shall not be recirculated but shall be removed through a drain located in the floor of the chamber.

After the exposure, the samples shall be removed from the chamber. The samples shall not be washed in any way, and care shall be taken so that any buildup of deposits is not disturbed.

The salt solution shall consist of 20 percent by weight of common salt (sodium chloride) and distilled water. The pH value of this solution as collected after spraying in the test apparatus shall be between 6.5 and 7.2, and the specific gravity between 1.126 and 1.157 at 95°F.

(e) **Moist Carbon Dioxide-Sulphur Dioxide-Air Mixture.** The test samples shall be supported vertically in a rectangular chamber of glass provided with a glass cover having openings for gas inlet and outlet. Chambers approximately 10 to 12 inches long, 8 to 10 inches wide, and 12 to 17 inches high have been found suitable for this test, but the size of the test chamber is not critical and its dimensions may be varied to accommodate the number and size of the samples to be tested.

Sulphur dioxide and carbon dioxide shall be supplied to the test chamber from commercial cylinders containing these gases under pressure. Once each working day the chamber shall be completely purged with fresh air, and an amount of sulphur dioxide equivalent to 1 percent of the volume of the test chamber and an equal volume of carbon dioxide shall be introduced into the chamber each working day. A small amount of water shall be maintained at the bottom of the chamber. The amount of sulphur dioxide and carbon dioxide introduced into the chamber may be measured by a gas burette or vertical calibrated glass tube provided at the lower end with a leveling bottle and fitted at the upper end with a three-way stopcock. One arm of the stopcock shall be connected to the cylinder containing sulphur dioxide and carbon dioxide, and the other arm shall be connected to the gas inlet of the test chamber. Mercury contained in the burette and in the leveling bottle shall be used as the confining and displacing liquid for the gas.

(f) **Moist Hydrogen Sulphide-Air Mixture.** The test samples shall be supported vertically in a rectangular chamber of glass provided with a glass cover having openings for gas inlet and outlet. Chambers approximately 10 to 12 inches long, 8 to 10 inches wide, and 12 to 17 inches high have been found suitable for this test, but the size of the test chamber is not critical and its dimensions may be varied to accommodate the number and size of the samples to be tested.

Hydrogen sulphide shall be supplied to the test chamber from a commercial cylinder containing the gas under pressure. Once each working day the chamber shall be completely purged with fresh air, and an amount of hydrogen sulphide equal to 1 percent of the volume of the test chamber shall be introduced into the chamber each working day. A small amount of water shall be maintained at the bottom of the chamber. The amount of hydrogen sulphide introduced into the test chamber may be measured with the apparatus described in Subsection (e), except that water, instead of mercury, is used as the confining and displacing liquid.

Wax Evaporation Test

Sec. 10.412. (a) **Wax Characteristics.** A wax used for coating a heat-responsive link shall not contain sufficient volatiles to cause shrinking, hardening, cracking or flaking of the applied coating.

(b) **Volatiles in Wax Coating.** When tested as specified in Subsection (c), the loss of volatile material shall not exceed 5 percent of the weight of the original sample.

(c) **Testing Procedure.** A 50-mL sample of the wax shall be placed in a metal or glass cylindrical container having a flat bottom, an inside diameter of 55 mm and an inside height of 35 mm. Containers, known as tin boxes or seamless ointment boxes, may be obtained in dimensions conforming to the above requirement. The container, without lid, shall be placed in an automatically controlled, electric-type, circulating-air, constant-ambient-temperature oven. The oven temperature shall be controlled as specified in the High Temperature—Coated Test, Section 10.409. The test shall be conducted for 90 days. During the test, the sample shall be removed from the oven at seven-day intervals and allowed to cool for two to four hours. After this cooling time, the sample shall be examined for evidence of change in any of the parts. The sample shall be weighed before and after the 90-day exposure to determine loss of volatiles.

Marking

Sec. 10.413. (a) **General.** Heat-responsive links shall be marked with the temperature rating, a distinctive type or model designation, and the manufacturer's or private labeler's name or identifying symbol.

(b) **Date of Manufacture.** The year of manufacture shall be stamped or cast on a visible area of the heat-responsive link. Links produced in the last three months of a calendar year may be marked with the following year as the date of manufacture, and those produced in the first three months of a calendar year may be marked with the preceding year as the date of manufacture.

(c) **Plated Links.** Plated heat-responsive links shall be provided with a distinctive identification.

(d) **More than One Factory.** If a manufacturer produces links at more than one factory, each unit shall have a distinctive marking to identify it as the product of a particular factory.

TABLE NO. 10-4-1
TEMPERATURE RATINGS

TEMPERATURE RATING	OPERATING TEMPERATURE DEGREES F.	MAXIMUM AMBIENT TEMPERATURE DEGREES F.
Low	125–130	90
Ordinary	135–170	100
Intermediate	175–225	150
High	250–300	225
Extra High	325–375	300
Very Extra High	400–475	375
Ultra High	500–575	475

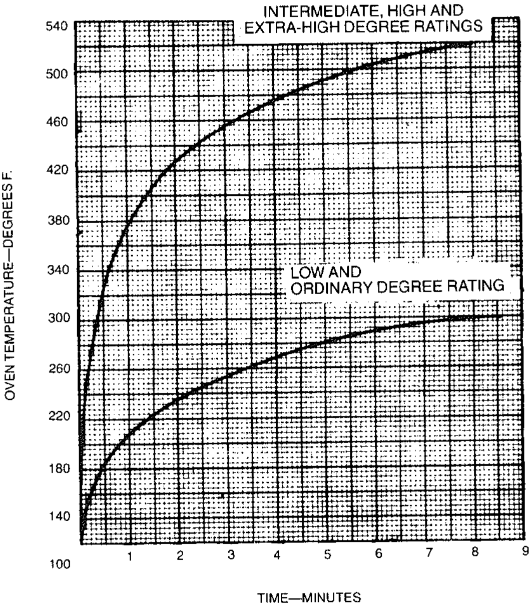
TABLE NO. 10-4-2
OPERATING TEMPERATURE RANGE

TEMPERATURE RATINGS, DEGREES F.	MAXIMUM ACTUAL OPERATING TEMPERATURE, DEGREES F.	MAXIMUM ACTUAL OPERATING TIME, MINUTES: SECONDS
125–130	245	2:30
135–170	290	6:30
175–225	445	2:30
250–300	475	4:00
325–375	505	6:30

TABLE NO. 10-4-3
HIGH-TEMPERATURE EXPOSURE TEST CONDITIONS

TEMPERATURE RATING RANGE, DEGREES F.	TEST TEMPERATURE DEGREES F. (±2°F.)
125–130	110
135–170	125
175–225	175
250–300	250
325–375	300
400–475	375
500–575	475

FIGURE NO. 10-4-1
AIR OVEN TESTS OF HEAT RESPONSIVE LINKS



UNIFORM MECHANICAL CODE STANDARD NO.10-5

STANDARD FOR INSTALLATION OF FACTORY-MADE AIR DUCTS

Based on the 1989 Fibrous Glass Duct Construction Standards published by the Thermal Insulation Manufacturers Association and the Guidelines for Installing Flexible Ducts published by the Air Diffusion Council.

See Section 1002 (b) of the Uniform Mechanical Code.

Note: This is a new standard.

Scope

Sec. 10.501. These requirements are intended to supplement information contained in the manufacturer's installation instruction sheets included in each carton of material, which cover fabrication, closure methods, reinforcement and hanging of factory-made rigid and flexible air ducts complying with U.M.C. Standard No. 10-1. The standard is divided into two parts: Part A covering rigid ducts and Part B covering flexible ducts.

Part A—Rigid Ducts

General

Sec. 10.502. The use of these ducts is governed by U.M.C. Section 1002 (a), together with the restrictions contained in Section 1004 (b). For information regarding the fabrication of rectangular ducts from flat sheets of duct board, refer to the document upon which this standard is based, and the manufacturer's instruction sheet.

Closure Systems

Sec. 10.503. (a) **General.** Closure systems are a vital element in the proper assembly of fibrous glass duct systems. They provide both the structural connection and sealing of seams and joints for air tightness. Only listed closure systems identified in the manufacturer's installation instructions are suitable for use with rigid fibrous glass duct systems. Listed closures include:

1. Pressure-sensitive aluminum foil tapes.
2. Heat-activated aluminum foil/scrim tapes.
3. Mastic and glass fabric tape systems.

Listed closure systems may be used on listed duct board materials.

(b) **Surface Preparation.** In order to obtain satisfactory adhesion and bonding, the surface on which closures will be applied must be free from dust, dirt, oil, grease, moisture and similar substances.

(c) **Joint and Seam Preparation.** Longitudinal seams are fabricated with a shiplap joint which is closed with the use of outward-clinching staples at 2 inches on center, through the stapling flap of the jacketing material. Transverse joints between two duct sections are prepared by joining two duct sections, pulling the staple flap over the adjoining section and stapling as shown in Figure No. 10-5-1.

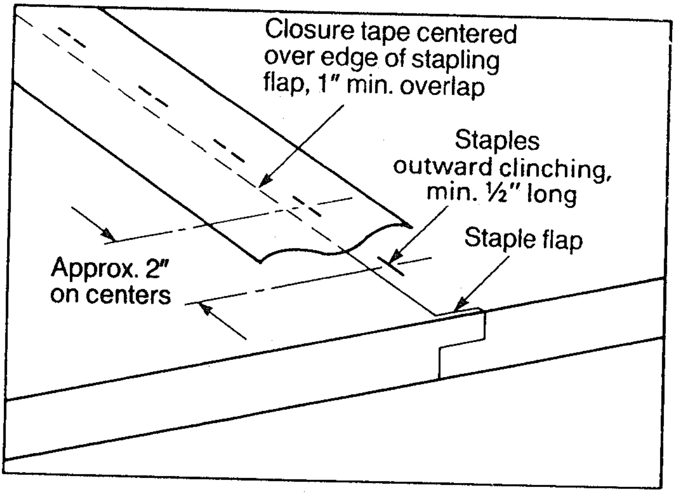

Closure tape centered over edge of stapling flap, 1" min. overlap
Staples outward clinching, min. ½" long
Staple flap
Approx. 2" on centers

FIGURE NO. 10-5-1—TAPE CLOSURE JOINT WITH STAPLE FLAP

When staple flaps are not present, crosstabs are used to hold seams and joints in position for reinforcing the closure system. Cross tabs, made from 8-inch minimum lengths of closure tape, are to be equally spaced on each side of the joint. Cross tabs are spaced on 12-inch (maximum) centers, with at least one cross tab per duct side (Figure No. 10-5-2). Cross tabs may be placed either under or over the closure tape.

(d) **Application of Pressure-sensitive Aluminum Foil Tapes.** Use minimum 2½-inch-wide listed pressure-sensitive tape. Position the tape along the edge of the flap in a manner that will allow 1-inch-minimum overlap on adjacent surfaces.

If tape has been stored at temperatures less than 50°F., it should be conditioned prior to use by placement in a warm environment in order to improve the initial tack.

If the duct board has been located in an atmosphere of less than 50°F., the surfaces to be taped must be preheated to assure a satisfactory bond of the tape. Using any suitable heating iron with the plate temperature set at 400°F. (±25°F.), preheat the area to be taped. Quickly position the tape on the preheated area and press in place. Pass the iron two or three times over the taped area using a rapid "ironing" motion (see Figure No. 10-5-5).

Rub tape firmly with a plastic squeegee (Figure No. 10-5-3) until the facing reinforcement shows through the tape.

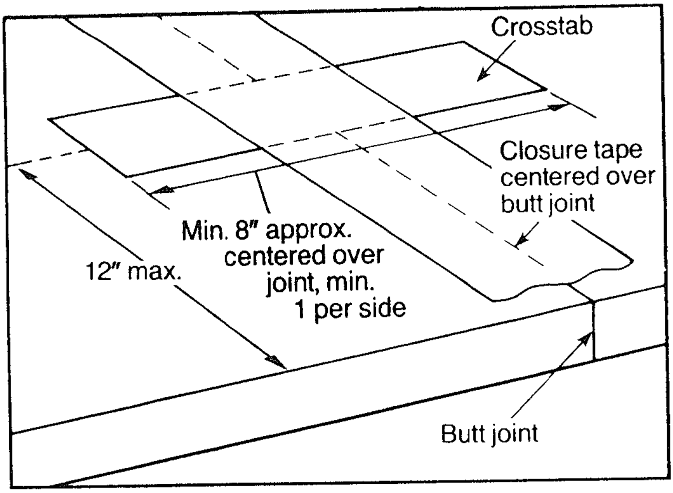

Crosstab
Closure tape centered over butt joint
Min. 8″ approx. centered over joint, min. 1 per side
12″ max.
Butt joint

FIGURE NO. 10-5-2—TAPE CLOSURE JOINT WITHOUT STAPLE FLAP

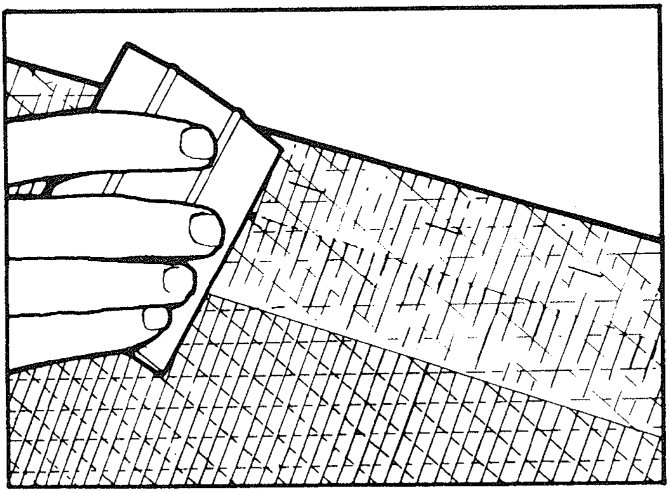


FIGURE NO. 10-5-3—PRESSURE-SENSITIVE TAPE

When operating pressure is less than 1 inch W.G. (positive pressure), and sheet metal surfaces are cleaned in accordance with tape manufacturer's instructions, pressure-sensitive tape may be used to seal fibrous glass duct to sheet metal.

(e) **Application of Heat-activated Tapes.** Position the 2½-inch (minimum) tape along the edge of the flap in a manner that will allow a 1-inch-minimum overlap on adjacent surfaces. Using a suitable heating iron with a plate temperature between 550°F. and 600°F., pass the iron along the tape seam with sufficient pressure and dwell time to activate the adhesive (see Figure No. 10-5-4). A satisfactory bond has been achieved when the heat indicator dots have darkened.

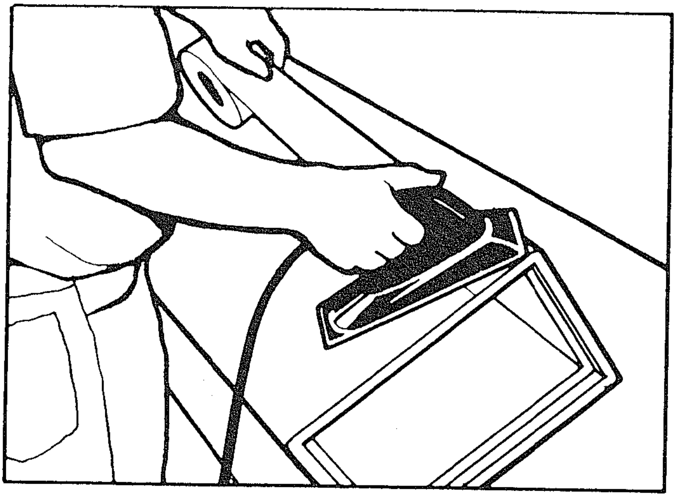


FIGURE NO. 10-5-4—HEAT-ACTIVATED TAPE

Use a second pass of the iron to complete the bond by applying pressure to the front edge of the iron in a smearing action (see Figure No. 10-5-5).

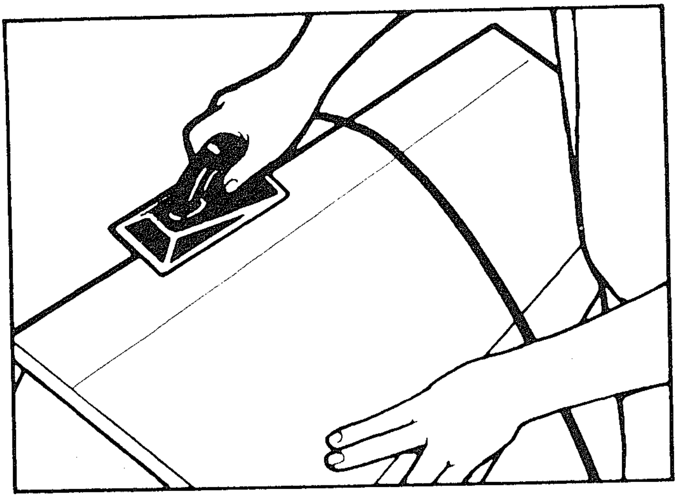


FIGURE NO. 10-5-5—HOT IRON, SECOND PASS

Allow all joints and seams to cool below 150°F. before any stress is applied. Avoid puncturing the tape at staple locations with excessive pressure from the iron.

(f) **Application of Glas-fab and Mastic Tape Systems.** Apply a thin coat of mastic approximately 3 1/2 inches wide over the center of the joint seam. Firmly press the 3-inch-wide glass fabric into the mastic (see Figure No. 10-5-6).

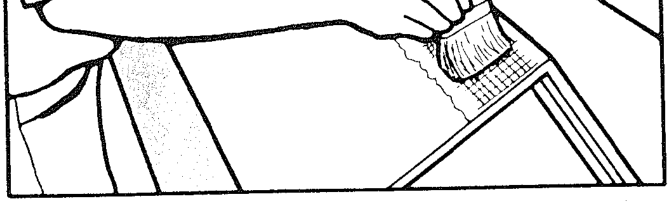


FIGURE NO. 10-5-6—GLASS FABRIC INTO MASTIC

Apply a second coat of mastic over the glass fabric, filling the scrim pattern as indicated in Figure No. 10-5-7.

Follow the manufacturer's label instructions on application rate, safety precautions, ventilation requirements, shelf life limitations and minimum setup time required before stress can be applied to the joint or seam.

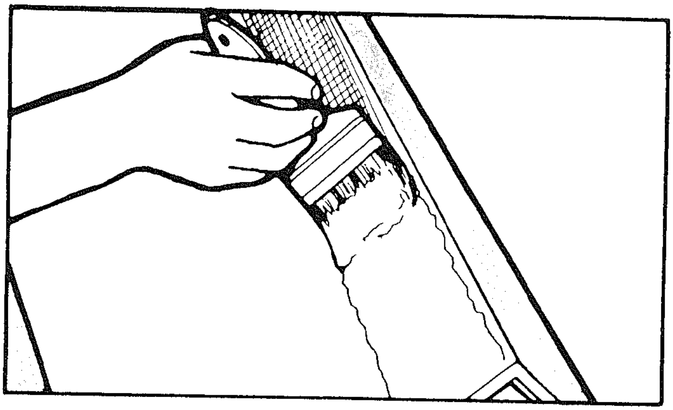


FIGURE NO. 10-5-7—SECOND COAT OF MASTIC

When connecting fibrous glass duct systems to sheet metal, as in connections to flanges or central air equipment, fasteners such as sheet metal screws and washers must be used to carry the mechanical load. Glass fabric and mastic can then be applied to seal the connections at these points. Usually, two widths of glass fabric will be required.

Reinforcement

Sec. 10.504. (a) **General.** Reinforcement is used to limit the deflection of the duct surface caused by internal static pressure loading. The maximum dimension of unreinforced ducts, which is a function of the system operating pressure, is shown on the manufacturer's label, affixed to each piece of duct board.

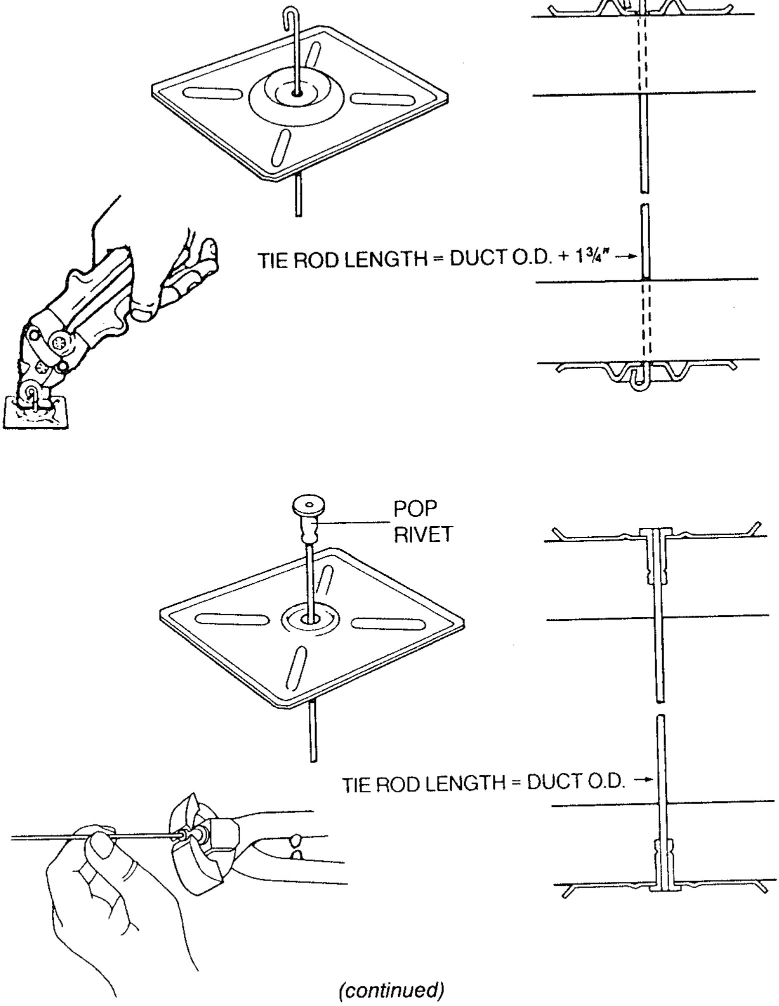
Duct systems made from Types 475 and 800 fibrous glass duct board may use one or more of the following reinforcement methods:

1. Tie rod reinforcement.
2. Channel reinforcement.

The reinforcement schedules contained in Tables Nos. 10-5-1, 10-5-2 and 10-5-4 are suitable for 0 inch to 2 inch W.G. duct systems.

While some duct dimensions may not require any reinforcement in straight sections, certain fittings of the same dimension may require reinforcement. This requirement is noted wherever applicable in this standard and in Table No. 10-5-4. Fitting reinforcement is accomplished by the use of tie rods wherever possible, and with channel reinforcement applied where tie rods cannot be used.

(b) **Tie Rod Reinforcement—Positive Pressure.** 1. **Tie rods.** Tie rods consist of straight lengths of 12 gauge galvanized steel wire with flat steel volcano-type washers and any of three approved termination devices (see Figure No. 10-5-8). The 2½-inch square shall be installed so turned edges face away from the duct board facing.



(continued)

FIGURE NO. 10-5-8—TERMINATIONS: FASLOOP; POP RIVET SLEEVE; LOCKING CAP

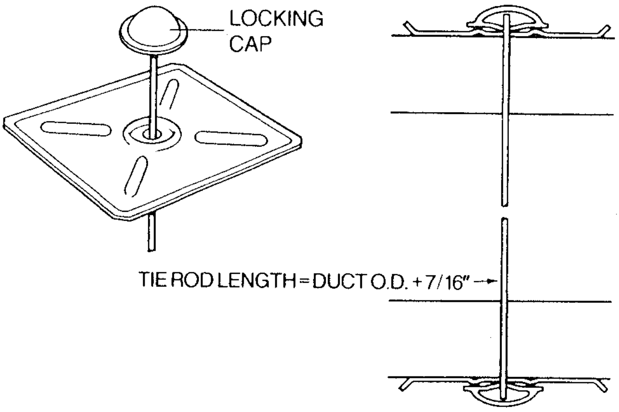


FIGURE NO. 10-5-8—TERMINATIONS: FASLOOP; POP RIVET SLEEVE; LOCKING CAP—(Continued)

2. **Location.** In relation to transverse joints, the tie rods are spaced 4 inches from the end of the female joint, as shown in Figure No. 10-5-9.

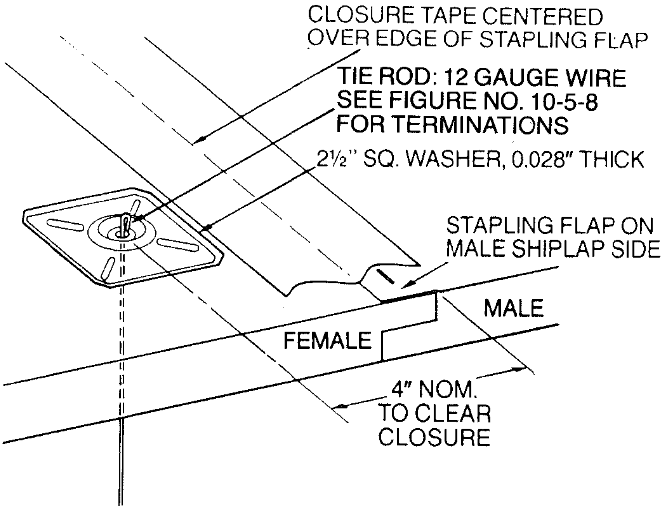

CLOSURE TAPE CENTERED OVER EDGE OF STAPLING FLAP
TIE ROD: 12 GAUGE WIRE SEE FIGURE NO. 10-5-8 FOR TERMINATIONS
2½" SQ. WASHER, 0.028" THICK
STAPLING FLAP ON MALE SHIPLAP SIDE
MALE
FEMALE
4" NOM. TO CLEAR CLOSURE

FIGURE NO. 10-5-9—TIE-ROD PLACEMENT

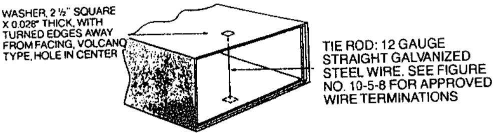
When butt joints are used instead of ship lap joints, tie rods are placed in rows located at 3 inches on either side of the joint.

Alternate: A single tie rod reinforcement may be used if the butt joint is glued with an adhesive system documented by the duct board manufacturer.

3. **Spacing.** Tie rods are placed in rows of 2 to 5 rods, across the face of the duct, with row spaces varying from 16 inches to 48 inches depending on duct size and operating pressure.

The spacing of tie rods is shown in Table No. 10-5-1.

TABLE NO. 10-5-1—TIE-ROD SYSTEM REINFORCEMENT SCHEDULE


WASHER, 2 ½" SQUARE X 0.028" THICK, WITH TURNED EDGES AWAY FROM FACING, VOLCANO TYPE, HOLE IN CENTER
TIE ROD: 12 GAUGE STRAIGHT GALVANIZED STEEL WIRE. SEE FIGURE NO. 10-5-8 FOR APPROVED WIRE TERMINATIONS

TIE-ROD SYSTEM REINFORCEMENT SCHEDULE (POSITIVE PRESSURE ONLY)

Positive Static Pressure	Maximum Inside Duct Dimension, Inches	TYPE 475 BOARD			TYPE 800 BOARD		
		No. Rods Across Dimension	Maximum Longitudinal Spacing	No. Rods Per 4 Ft. Section	No. Rods Across Dimension	Maximum Longitudinal Spacing	No. Rods Per 4 Ft. Section
0 thru ½" W.G.	0-36		*			*	
	37-42	2	24"	4	2	48"	2
	43-48	↓	↓	↓	↓	↓	↓
	49-60	3	↓	6	3	↓	3
	61-64	↓	↓	↓	↓	24"	6
	65-80	4	↓	8	4	↓	8
	81-96	5	↓	10	5	↓	10
Over ½" thru 1" W.G.	0-24		*			*	
	25-30	1	24"	2	1	48"	1
	31, 32	↓	↓	↓	↓	24"	2
	33-36	2	↓	4	2	↓	4
	37-48	↓	↓	↓	↓	↓	↓
	49-64	3	↓	6	3	↓	6
	65-80	4	↓	8	4	↓	8
	81-96	5	↓	10	5	↓	10
Over 1" thru 2" W.G.	0-15		*			*	
	16-18	1	24"	2		*	
	19-24	↓	↓	↓	1	24"	1
	25-32	↓	16"	3	↓	24"	2
	33-48	2	↓	6	2	↓	4
	49-60	3	↓	9	3	↓	6
	61-64	↓	↓	↓	↓	16"	9
	65-80	4	↓	12	4	↓	12
	81-96	5	↓	15	5	↓	15

*Straight ducts of these dimensions do not require reinforcement. However, some fittings of these dimensions may require reinforcement.

NOTES: 1. Tie rods and washers must be no more than 16" on centers across duct dimension.
2. Ducts of 48" width and over require use of anti-sag devices. See Figs. 4-3b, page 4-4 and 4-5b, page 4-5.
3. For duct dimensions over 96", maintain tie rod spacing on 16" centers across the duct dimension following longitudinal spacing for the design pressure.

When the sides of the duct exceed the dimensions which require reinforcement (see Table No. 10-5-1), horizontal tie rods are also installed per the schedule.

4. **Typical tie-rod reinforcement examples, positive pressure ducts.** See Section 10.504 (b) 2 for placement of tie rods and sag supports in relation to joints. Sag support is required in ducts 48 inches and greater in width.

The number of tie rods across the duct width shall be as required in the schedule contained in Table No. 10-5-1.

The longitudinal spacing of the rows of tie rods is based upon the schedule in Table No. 10-5-1. This spacing will vary from 48 inches on center to as close as 16 inches on center.

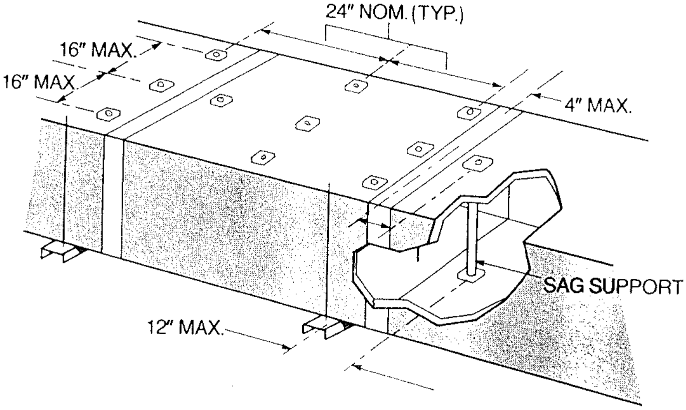


FIGURE NO. 10-5-10—TIE ROD REINFORCEMENT ROWS ON 24-INCH CENTERS, 48-INCH DUCT SECTION

5. **Sag control—tie-rod reinforcement shiplapped joints.** Top panels of fibrous glass duct sections or fittings, 48 inches wide or greater, may sag due to the weight of the duct board when the system is not pressurized. To control this condition, sag supports must be provided. Figure No. 10-5-11A shows a typical installation.

Sag supports do not replace tie-rod assemblies as called for in the reinforcement schedule, but must be installed in addition to them. Hangers must be located within 12 inches of the sag supports.

For easier mating of fittings and duct sections during installation, a $^1/_2$-inch-diameter steel conduit and washers may be added to an existing tie-rod assembly at the female shiplap end.

When ducts are fabricated with butt joints, sag supports must be installed on both sides of the joint. A hanger must be installed within 12 inches of the sag support.

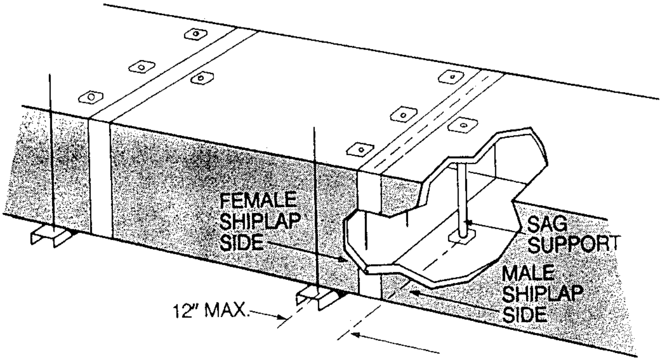


FIGURE NO. 10-5-11A—SAG CONTROL—TIE ROD REINFORCEMENT

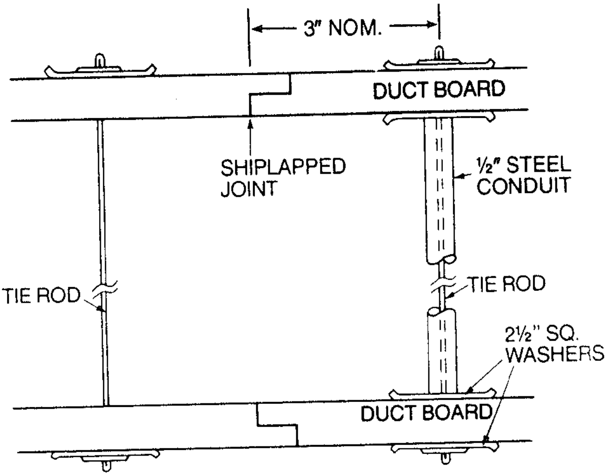


FIGURE NO. 10-5-11B—SAG CONTROL DETAIL

(c) **Channel Reinforcement.** 1. **General.** Another reinforcement system, for use in either positive or negative pressure duct systems, consists of formed sheet metal channels wrapped around the perimeter of the duct.

When channels must be attached to the duct, for sag control or negative-pressure reinforcement, No. 10 plated sheet metal screws and 2 1/2-inch square, 0.020-inch (minimum) thick sheet metal washers are used. These must have turned edges to prevent cutting into the duct board. In positive-pressure applications wraparound channels need not be attached to the duct board except when required for sag control.

TABLE NO. 10-5-2—CHANNEL SYSTEM REINFORCEMENT SCHEDULE

CHANNEL SYSTEM REINFORCEMENT SCHEDULE

Static Pressure,		Maximum Inside Duct Dimension (I.D.), in.	TYPE 475 BOARD			TYPE 800 BOARD		
			Maximum longitudinal spacing	Channel gage	H dimension (see below)	Maximum longitudinal spacing	Channel gage	H dimension (see below)
0 thru ½" W.G.	negative	0-30	*			*		
		31-36	24"	22	1"	48"	22	1"
	positive	0-36	*			*		
0 thru ½" W.G. positive or negative		37-42	24"	22	1"	48"	22	1"
		43-48	↓	↓	↓	↓	↓	↓
		49-60	↓	↓	↓	↓	↓	1½"
		61-72	↓	↓	↓	24"	↓	1"
		73-84	↓	↓	↓	↓	↓	↓
		85-96	↓	↓	1¼"	↓	↓	↓
Over ½" thru 1" W.G. positive or negative		0-24	*			*		
		25-30	24"	22	1"	48"	22	1"
		31-36	↓	↓	↓	24"	↓	↓
		37-42	↓	↓	↓	↓	↓	↓
		43-48	↓	↓	↓	↓	↓	↓
		49-60	↓	↓	↓	↓	↓	↓
		61-72	↓	18	↓	↓	18	↓
		73-84	↓	↓	1¼"	↓	↓	1¼"
		85-96	↓	↓	↓	↓	↓	↓
Over 1" thru 2" W.G. positive or negative		0-15	*			*		
		16-18	24"	22	1"	*		
		19-24	↓	↓	↓	24"	22	1"
		25-36	16"	↓	↓	↓	↓	↓
		37-48	↓	↓	↓	↓	↓	1¼"
		49-60	↓	↓	↓	↓	↓	↓
		61-72	↓	18	↓	16"	18	1"
		73-84	↓	↓	1¼"	↓	↓	1¼"
		85-96	↓	↓	1½"	↓	↓	1½"

*Straight ducts of these dimensions do not require reinforcement. However, some fittings of these dimensions may require reinforcement.

NOTE: 1 Ducts of 48" maximum width and over require use of anti-sag devices.

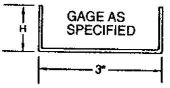


Table No. 10-5-2 gives longitudinal spacing, sheet metal gage and channel height dimensions of reinforcement, depending on the duct board type, maximum inside dimensions and static pressure. This is a minimum reinforcement schedule applying to straight sections. This schedule will also apply to fittings, but a simplified schedule may also be used (see Table No. 10-5-3).

2. **Channels.** Channels must be fabricated from galvanized sheet metal of the gage shown in Table No. 10-5-2.

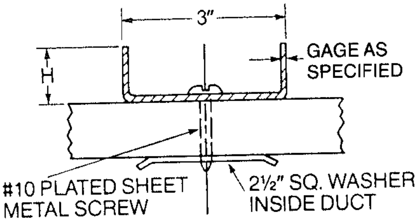
Channels are 3 inches wide, with a height (*H*) as shown in Table No. 10-5-2.

Each reinforcement may be fabricated from a continuous length of channel having three 90-degree bends and a fourth 90-degree corner which is fastened with bolts, screws, rivets, spot welds or staples. Reinforcements may also be fabricated with two, three or four securely fastened corners.

3. **Location of channels.** Channels are normally offset 4 inches from the end of the duct section to facilitate installation of sag supports and the closure system.

Where wraparound channels without sag support are used, the channel is slipped over the closure tape after the tape is applied, centered over the female shiplap end for maximum support.

4. **Sag support and typical channel reinforcement.** When the duct is 48 inches wide or greater, channels are secured to the top for sag support with No. 10 plated sheet metal screws and 2 1/2-inch square washers (see Detail A). The number of channels along the duct shall be in accordance with Table No. 10-5-2.



DETAIL Ⓐ

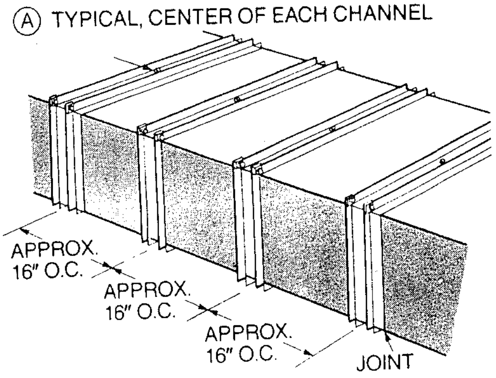
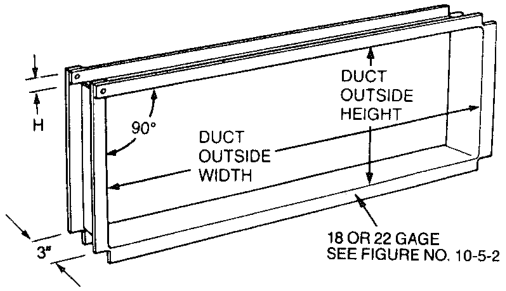


FIGURE NO. 10-5-12—16-INCH CENTERS, 48-INCH DUCT SECTIONS

(d) **Negative-pressure Channel Reinforcement.** 1. **Locating reinforcing channels.** In negative-pressure applications such as return-air ducts, the channel reinforcement is applied over the male shiplap. Special clips are installed inside the duct (see Figure No. 10-5-13), which will support both the male and female sides of the duct joint. The clips are fastened in place with two sheet metal screws.



DETAIL B. CHANNEL REINFORCEMENT

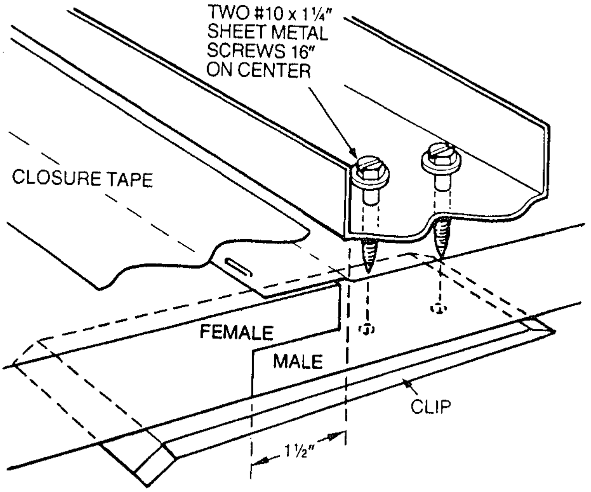
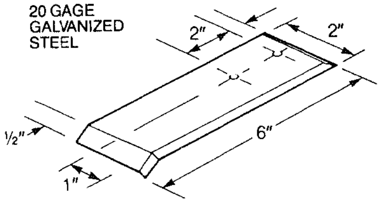


FIGURE NO. 10-5-13—CHANNEL REINFORCEMENT FOR NEGATIVE PRESSURE SYSTEMS

2. **Clips.** Clips are formed from 20 gage galvanized steel, with turned edges as shown in Detail B.

Clips are spaced not more than 16 inches apart and not more than 16 inches from the sides of a duct. The number of clips required is shown in Table No. 10-5-3.



DETAIL A. CLIP, NEGATIVE PRESSURE REINFORCEMENT SYSTEMS

FASTENER REQUIREMENTS, NEGATIVE PRESSURE	
Transverse Dimension	Minimum number of clips or washers per reinforcing member
16"-32"	1
33"-48"	2
49"-64"	3
65"-80"	4
81"-96"	5

TABLE NO. 10-5-3—DETAIL B—CLIP, NEGATIVE PRESSURE SYSTEMS

(Note: The foregoing arrangements are important and, if not followed closely, may result in system failure.)

3. **Additional fasteners.** When additional channels are required (as with 24-inch and 16-inch spacing), they are attached to the duct with No. 10 plated sheet metal screws and 2½-inch square washers (see Detail A of Figure No. 10-5-12).

The spacing of the fasteners through each reinforcement channel is the same as for joint clips (see Table No. 10-5-3). A typical layout for negative pressure ductwork is shown in Figure No. 10-5-14 and Detail C.

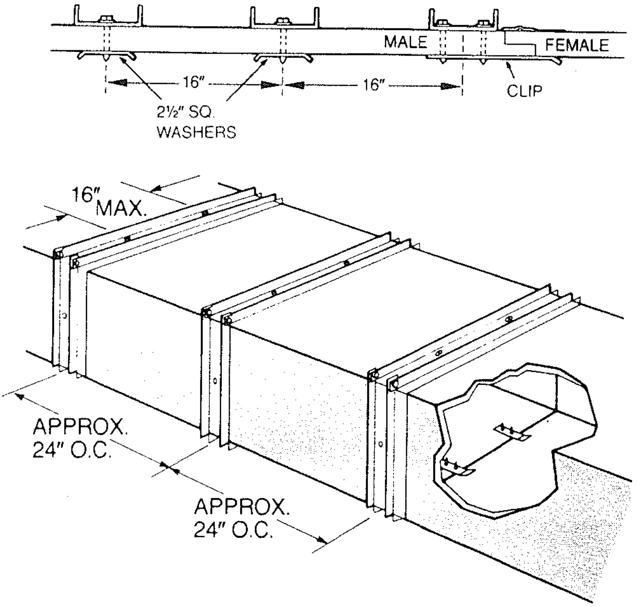
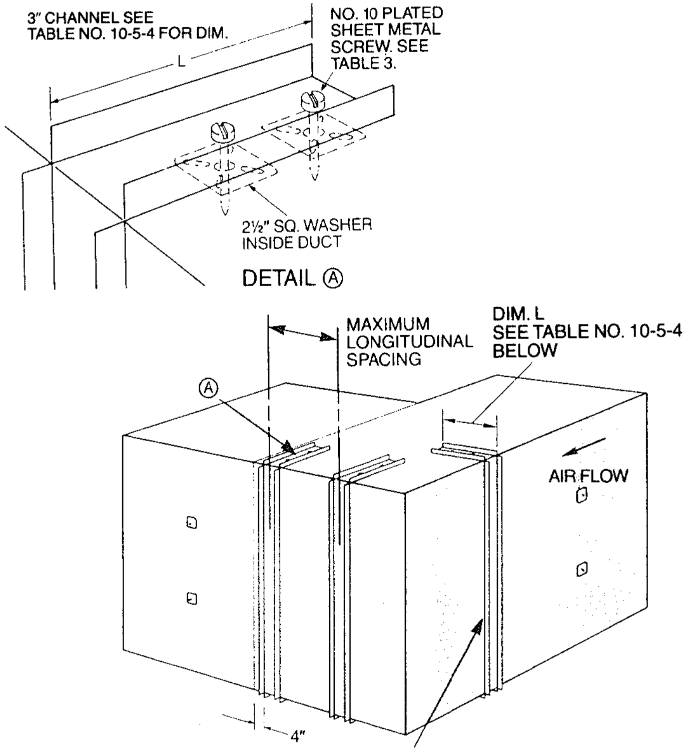


FIGURE NO. 10-5-14—CHANNEL REINFORCEMENT ON 24-INCH CENTERS, 48-INCH DUCT SECTION.

(e) **Fitting Reinforcement—Positive-pressure Systems.** 1. **General.** Fittings are reinforced with tie rods or channels based upon the duct dimensions, using the criteria found in Tables Nos. 10-5-1 and 10-5-2.

Some fittings, branches, tees or offsets, may require reinforcement even though schedules for straight ducts of the same dimension may show reinforcement is not required.

2. **Partial wraparound reinforcement.** Where reinforcement is required but cannot be fastened to opposite sides of a duct section or fitting, it is necessary to install formed sheet metal channels that partially wrap around a fibrous glass duct system fitting at the required location. (See Table No. 10-5-2 for appropriate gage and profile). In such cases, No. 10 by 1 1/4-inch plated sheet metal screws and 2 1/2-inch square washers, 0.020 inch (minimum) thick, are used to attach the ends of the channels to the duct board. (See Detail D and Table No. 10-5-4.)



TOTAL LENGTH OF CHANNEL =
OUTSIDE DUCT DIMENSION + TWICE L DIM., TABLE NO. 10-5-4

FIGURE NO. 10-5-15—PARTIAL WRAP-AROUND REINFORCEMENT

TABLE NO. 10-5-4—PARTIAL WRAP-AROUND REINFORCEMENT

PARTIAL WRAP-AROUND REINFORCEMENT SCHEDULE								
	TYPE 475 BOARD				TYPE 800 BOARD			
Positive static Pressure	Maximum Inside Duct Dimension, Inches	Longi-tudinal spacing	Dimen-sion L	No. of screws, each end	Maximum Inside Duct Dimension, Inches	Longi-tudinal spacing	Dimen-sion L	No. of screws, each end
0" thru ½" W.G.	0-36	NOT REQUIRED			0-36	NOT REQUIRED		
	37-96	24"	4"	1	37-60	48"	4"	1
					61-96	24"	↓	↓
Over ½" thru 1" W.G.	0-24	NOT REQUIRED			0-24	NOT REQUIRED		
	25-48	24"	4"	1	25-30	48"	4"	1
	49-64	↓	7"	2	31-48	24"	↓	↓
	65-80	↓	10"	3	49-64	↓	7"	2
	81-96	↓	13"	4	65-80	↓	10"	3
					81-96		13"	4
Over 1" thru 2" W.G.	0-15	NOT REQUIRED			0-18	NOT REQUIRED		
	16-24	24"	4"	1	19-24	24"	4"	1
	25-32	16"	↓	↓	25-32	↓	7"	2
	33-48	↓	7"	2	33-48	↓	10"	3
	49-64	↓	10"	3	49-60	↓	13"	4
	65-80	↓	13"	4	61-64	16"	10"	3
	81-96	↓	16"	5	65-80	↓	14"	↓
					81-96	↓	16"	5

3. **Fitting reinforcement—90-degree elbows.** If neither dimension A nor B (see Figure No. 10-5-16) are greater than the maximum unreinforced duct dimension (see Table No. 10-5-1), but diagonal X-Y is greater than the maximum unreinforced duct dimension in accordance with Table No. 10-5-1, install tie-rod reinforcement at midspan of diagonal at point No. 1 in Figure No. 10-5-16.

If either A or B is greater than the maximum unreinforced duct dimension:

Reinforce in accordance with Table No. 10-5-1.

Reinforce 4 inches upstream from female shiplap joints.

Reinforce at point No. 1 (Figure No. 10-5-16) where center lines intersect.

(Note: Turning vanes in Figure No. 10-5-16 are omitted for clarity. Turning vanes do not replace reinforcement.)

Heel and Throat Panels. If duct dimension *H* (see Figure No. 10-5-17) is less than the maximum unreinforced duct dimension from Table No. 10-5-1, but more than 24 inches, install sheet metal angle in accordance with Detail E below. (Angle may also be installed on inside of throat.)

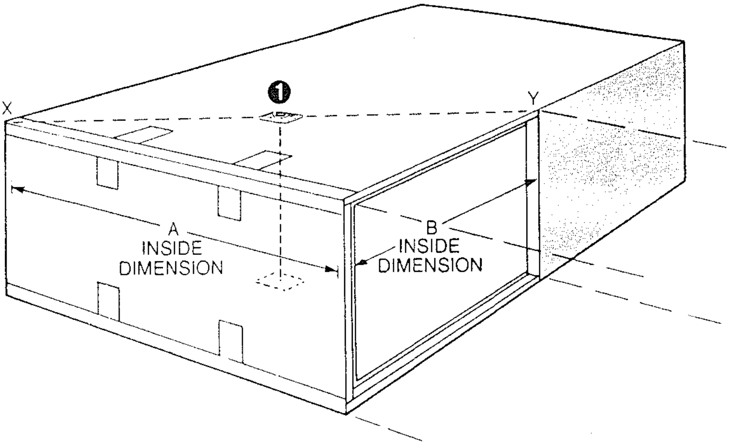
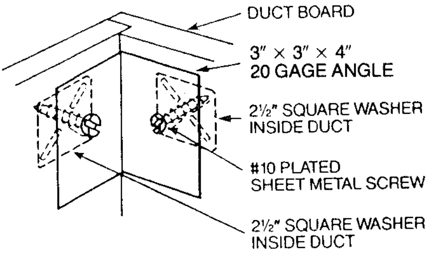
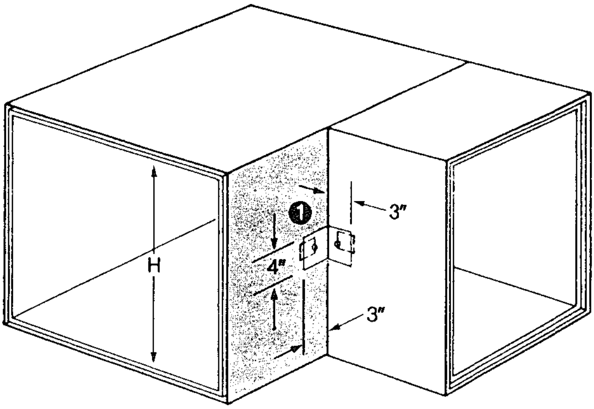
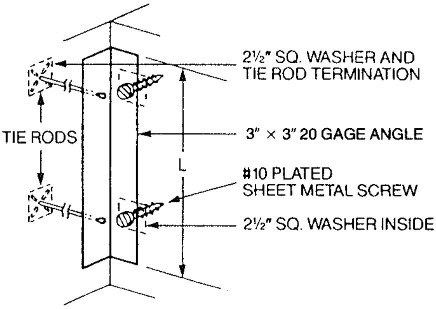


FIGURE NO. 10-5-16—TIE ROD REINFORCEMENT AT DIAGONAL X-Y—MIDSPAN



DETAIL E—THROAT REINFORCEMENT




2½" SQ. WASHER AND TIE ROD TERMINATION
TIE RODS
3" × 3" 20 GAGE ANGLE
L
#10 PLATED SHEET METAL SCREW
2½" SQ. WASHER INSIDE

DETAIL F—THROAT REINFORCEMENT

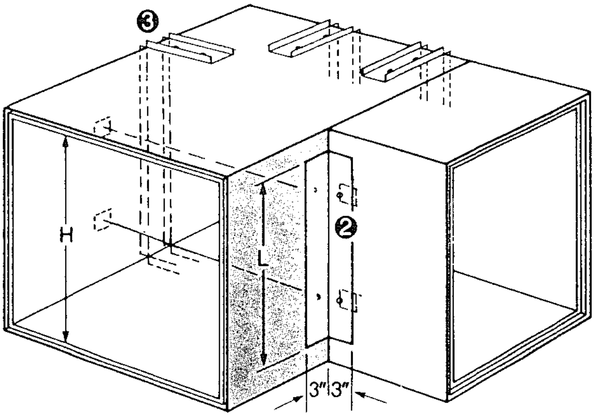


FIGURE NO. 10-5-17—SHEET METAL ANGLE AT THROAT LARGE 90-DEGREE ELBOWS

When duct dimension *H* normally requires reinforcing, install sheet metal angle as shown at No. 2, Figure No. 10-5-17 and Detail F. Install tie rods through angle on upstream side, 16 inches on centers, in accordance with Table No. 10-5-1, with angle of length *L* from table below.

No. Tie Rods	1	2	3	4	5
Angle Length L, in.	4	20	36	52	68

Install 3-inch channel reinforcement on heel panels as shown in Figure No. 10-5-17, spaced in accordance with Table No. 10-5-4 and fastened in accordance with Figure No. 10-5-15.

(Note: Attachment of angles is best done after closure is completed. This requires sections to be short enough to allow the installer to reach inside to install the 2½-inch square washers.)

(Note: For reinforcement of mitered elbows, refer to reinforcement standards for offsets.)

4. **Branch connections (tees).** Many branches may require reinforcement even though schedules for straight ducts of the same dimensions may show reinforcement is not required.

Angled branches and positive takeoffs may be reinforced using the same methods as for tees. The amount and type of reinforcement depends on the dimensions of the takeoff and the system pressure (see Table No. 10-5-1).

If *H* is not greater than 16 inches and *W* (see Figure No. 10-5-18) is greater than 12 inches, install reinforcement in accordance with Detail E on the top of the branch where it intersects the trunk duct.

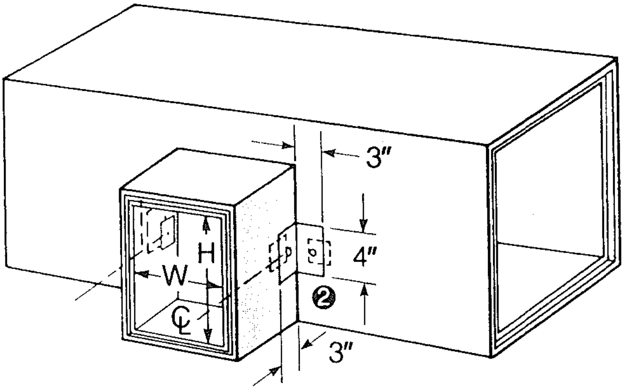


FIGURE NO. 10-5-18—SHEET METAL ANGLE REINFORCEMENT; SIDES OF BRANCH

If *H* is greater than 16 inches and *W* is less than the maximum unreinforced duct dimension, reinforce side of branch as shown at No. 2, Figure No. 10-5-18.

(Note: The maximum unreinforced dimension is 36 inches at ½ inch W.G., 24 inches at 1 inch W.G., and 16 inches at 2 inches W.G.)

If *H* (Figure No. 10-5-18) is greater than 16 inches and *W* is greater than the maximum unreinforced duct dimension (see Table No. 10-5-1) install long angle clips in accordance with Detail C of Figure No. 10-5-14 with tie-rod reinforcement through the branch and trunk ducts (similar to Figure No. 10-5-17) as required by Table No. 10-5-1. A combination of tie rods and partial wraparound reinforcement (see Figure No. 10-5-15) may be used.

If *A* (see Figure No. 10-5-19) is less than the maximum unreinforced duct dimension but diagonals X-Y or Y-Z exceed the maximum allowable unreinforced duct dimension, install tie rods as shown at No. 2, 4 inches from female shiplaps.

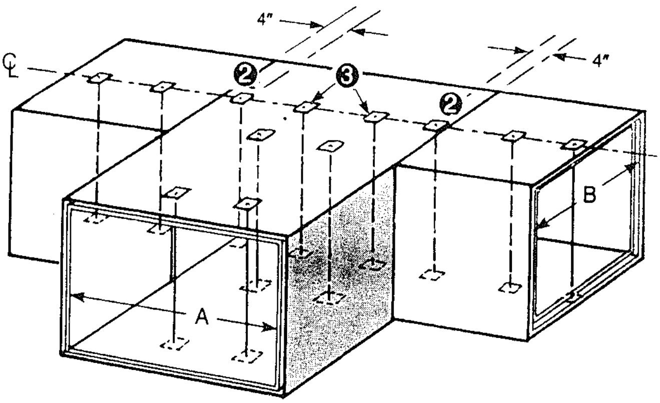


FIGURE NO. 10-5-19—TEE REINFORCEMENT NORMAL TIE ROD LOCATIONS

If *A* is greater than the maximum unreinforced duct dimension and *B* is greater than one half the maximum unreinforced duct dimension, install tie rods 4 inches from female shiplap joints as shown at No. 2 and also along branch center lines and, additionally, spaced per Table No. 10-5-4 in the trunk duct.

Where a splitter damper interferes with tie-rod reinforcement, wraparound channels must be used in their place.

(Note: Turning vanes do not replace reinforcement.)

5. **Offsets.** Offsets require different types of reinforcement for the cheek panels (sides, as shown in Figure No. 10-5-20) and the heel and throat panels (top and bottom, per Figure No. 10-5-21).

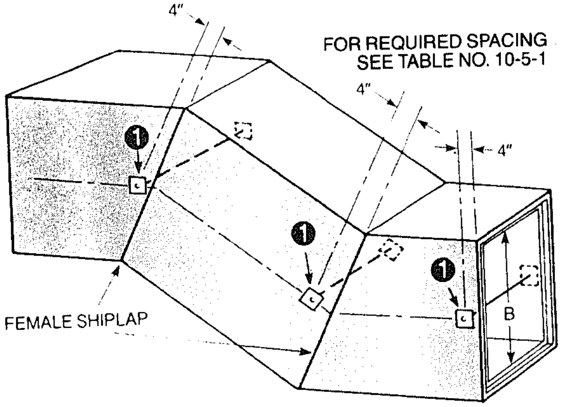


FIGURE NO. 10-5-20—OFFSET REINFORCEMENT CHEEK PANELS WITH SHIPLAP JOINTS

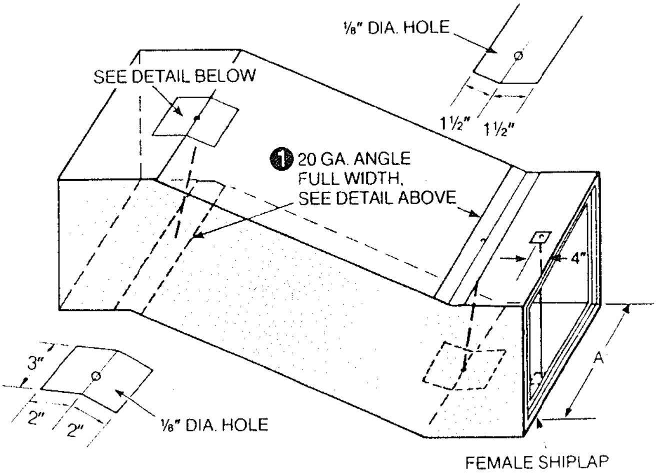


FIGURE NO. 10-5-21—OFFSET REINFORCEMENT WITH SHEET METAL PLATES AND TIE RODS

If *B* is greater than the maximum unreinforced duct dimension and cheek panels have shiplap joints, reinforce in accordance with No. 1, 4 inches from female shiplap (see Figure No. 10-5-20) with spacing in accordance with Table No. 10-5-1.

If the fitting uses butt joints, install the required spacing of tie rods 3 inches on each side of the butt joint.

Where Table No. 10-5-1 requires more than one row of reinforcement, the rows shall be parallel to the edges of the duct, and the spacing between sets of tie rods shall be in accordance with Table No. 10-5-1.

The reinforcement for heel and toe joints is in accordance with Figure No. 5-10-21. Additional tie rods may be installed by using a longer plate at the heel, and also in the duct panel spaced in accordance with Table No. 10-5-1. The penetrations at the toe plate are grouped as close to the break in the metal as possible.

When dimension *A* requires more than one tie rod (see Table No. 10-5-1), sets of tie rods with metal angles shall be installed in rows parallel to the side of the duct.

Transitions are reinforced in the same manner with a tie rod extending from the flat side of the duct, through a plate or plates positioned on 12 the heel joint of the fitting.

6. **Access doors—positive pressure.** If the access door width is not greater than the maximum longitudinal reinforcement spacing from Table No. 10-5-1, but interferes with reinforcement locations required by the table, install tie rods 4 inches from both sides of door opening in accordance with No. 1, Figure No. 10-5-22. Maximum reinforcement spacing must be in accordance with Table No. 10-5-1.

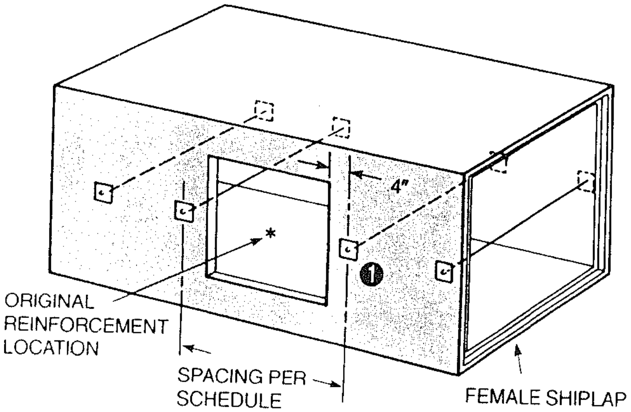


FIGURE NO. 10-5-22—ACCESS DOOR LOCATION INTERFERING WITH REINFORCEMENT

If access door height is greater than 16 inches and its width is greater than the maximum longitudinal reinforcement spacing shown in Table No. 10-5-1, install the frame for the access door inside the duct, securing it to the duct wall with screws and washers (see Figure No. 10-5-23).

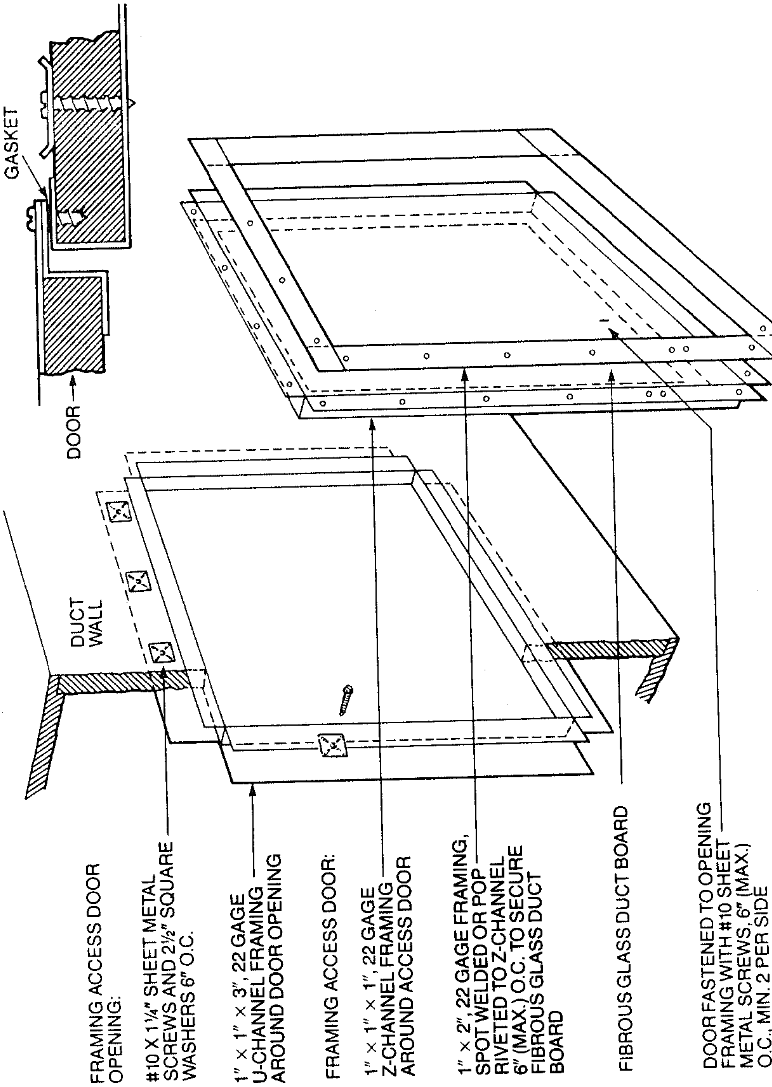
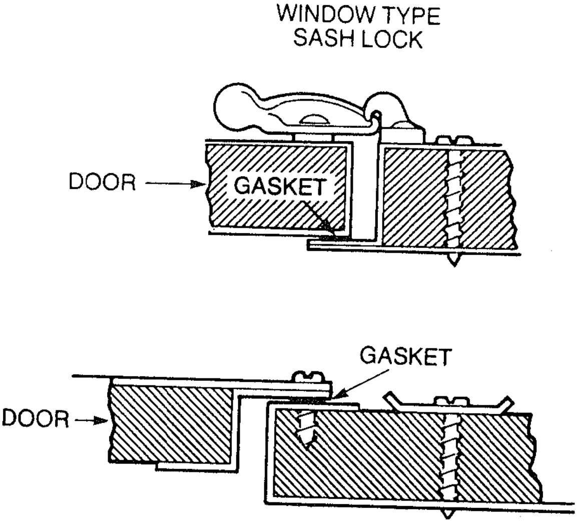

GASKET
DOOR
DUCT WALL
FRAMING ACCESS DOOR OPENING:
#10 X 1¼" SHEET METAL SCREWS AND 2½" SQUARE WASHERS 6" O.C.
1" × 1" × 3", 22 GAGE U-CHANNEL FRAMING AROUND DOOR OPENING
FRAMING ACCESS DOOR:
1" × 1" × 1", 22 GAGE Z-CHANNEL FRAMING AROUND ACCESS DOOR
1" × 2", 22 GAGE FRAMING, SPOT WELDED OR POP RIVETED TO Z-CHANNEL 6" (MAX.) O.C. TO SECURE FIBROUS GLASS DUCT BOARD
FIBROUS GLASS DUCT BOARD
DOOR FASTENED TO OPENING FRAMING WITH #10 SHEET METAL SCREWS, 6" (MAX.) O.C., MIN. 2 PER SIDE

FIGURE NO. 10-5-23—DUCT OPENING FRAME

Install tie rods near the vertical sides of the door (Figure No. 10-5-22) frame and also near the top and bottom sides of the frame, spaced as specified in Table No. 10-5-1 with a minimum of one tie rod on each side of the frame.

(Note: Use channel reinforcement in place of tie rods between access door and fire damper where tie rods would interfere with damper access or operation.)

The duct door is fabricated from 1 inch duct board installed with 1-inch by 1-inch by 1-inch, 22 gauge Z-channel framing around access door. Doors are gasketed and secured in place with sheet metal screws, or they may be hinged with sash lock fasteners as shown in Detail G.



DETAIL G—WINDOW-TYPE SASH LOCK FLANGED DOOR

Fire Dampers

Sec. 10.505. When fire dampers are required at penetrations of fire-rated walls, fibrous glass ducts must terminate at either side of such walls. Fire dampers shall be installed in accordance with the damper manufacturer's instructions and must be installed in a steel sleeve. The opening in the wall shall be large enough to allow for thermal expansion of the sleeve and to permit installation of $^5/_8$-inch gypsum board between the sleeve and framing.

The sleeve must extend not less than 3 inches beyond the face of the wall so that the duct can be slipped onto the sleeve. The duct is secured to the sleeve with screws and washers, as shown in Figure No. 10-5-24.

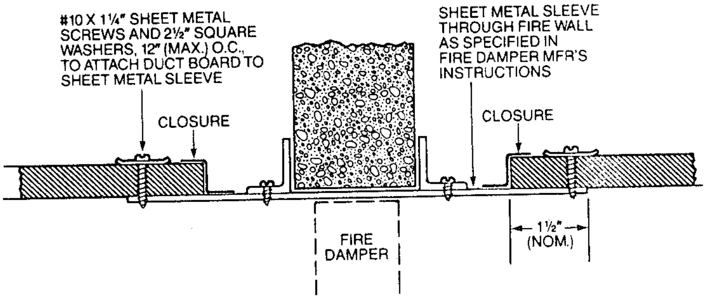

#10 X 1¼" SHEET METAL SCREWS AND 2½" SQUARE WASHERS, 12" (MAX.) O.C., TO ATTACH DUCT BOARD TO SHEET METAL SLEEVE
CLOSURE
SHEET METAL SLEEVE THROUGH FIRE WALL AS SPECIFIED IN FIRE DAMPER MFR'S INSTRUCTIONS
CLOSURE
FIRE DAMPER
1½" (NOM.)

FIGURE NO. 10-5-24—ATTACHMENT TO FIRE DAMPER SLEEVES

Sealing of fibrous glass duct board to the sheet metal sleeve must be made with glass fabric and mastic, except where operating pressure is less than 1-inch W.G. and sheet the metal surfaces are carefully cleaned, in which case pressure-sensitive aluminum foil tape may be used. See Section 10.503, Closure Systems, for methods.

Hangers and Supports

Sec. 10.506. (a) **General.** Fibrous glass ducts are light in weight, so that they can be supported with a minimum of hangers if care is taken as to placement of the supports.

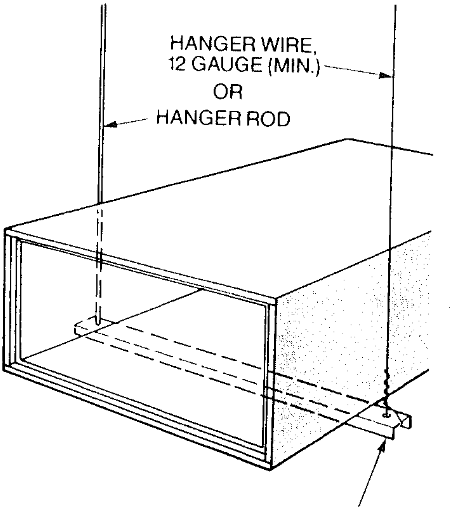

HANGER WIRE,
12 GAUGE (MIN.)
OR
HANGER ROD
CHANNEL (SEE TABLE NO. 10-5-6 FOR SHEET METAL GAGE AND DIMENSIONS)

FIGURE NO. 10-5-25—TYPICAL HANGER

The charts and examples illustrated in this section show that the hanger treatment and spacing required is dependent on duct dimensions. Trapeze-style channels, suspended by 12 gauge (minimum) hanger wire (see Figure No. 10-5-25) are the preferred method of support. Channel gage and profile vary with duct size, but in no case should the supporting channel be less than 2 inches wide. Channels may also be suspended by means of metal rods of 1-inch-wide (minimum) galvanized steel straps.

When channel reinforcement members occur within maximum hanger spacing as shown in Table No. 10-5-5, sheet metal straps may be bolted to the channel reinforcement as shown in Figure No. 10-5-26. Support may also be made with 12 gauge (minimum) wire.

TABLE NO. 10-5-5

DUCT SIZE, INCHES	MAXIMUM HANGER SPACING
48" Wide or greater	4 Ft.
Less than 48" wide and less than 12" deep	6 Ft.
Width between 24" & 48" and greater than 24" deep	6 Ft.
Less than 48" wide and depth between 12" & 24"	8 Ft.
Width 24" or less and depth greater than 12"	8 Ft.

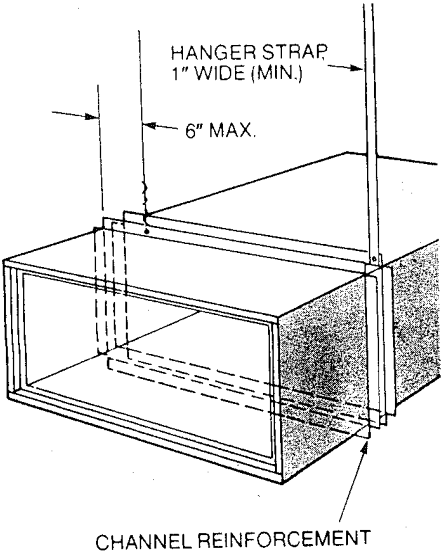


FIGURE NO. 10-5-26—HANGING FROM CHANNEL REINFORCEMENT

(b) **Hanger Design.** Occasionally, hanger channels must be extended considerably beyond the duct sides so that the supports will clear other obstructions. The total extension (*E* + *E*′) of the supports beyond the duct sides (see Figure No. 10-5-27), governs the minimum dimensions (see Table No. 10-5-6) of the channel.

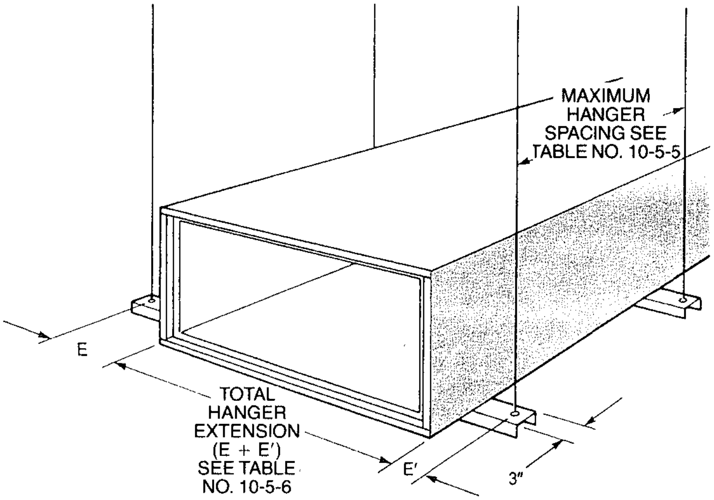

MAXIMUM HANGER SPACING SEE TABLE NO. 10-5-5
E
TOTAL HANGER EXTENSION (E + E′) SEE TABLE NO. 10-5-6
E′
3″

FIGURE NO. 10-5-27—HANGER SPACING AND EXTENSION USING 3-INCH-WIDE CHANNELS

TABLE NO. 10-5-6—CHANNEL SELECTION

IF TOTAL EXTENSION IS NOT GREATER THAN:	MINIMUM CHANNEL GAGE	MINIMUM CHANNEL PROFILE
6″	24	3″ X 1.5″
18″	22	3″ X 2″
30″	18	3″ X 2″

(c) Spacing. Hanger spacing per Table No. 10-5-5 or Figure No. 10-5-28 is based upon 3-inch-wide (minimum) channels.

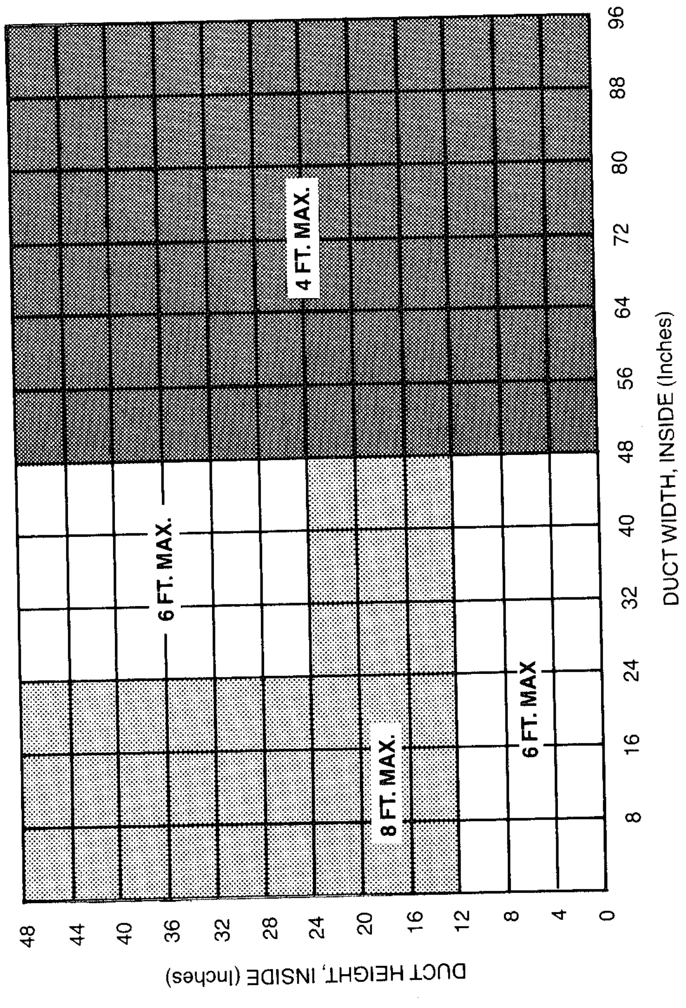


FIGURE NO. 10-5-28—MINIMUM HANGER SPACING, STRAIGHT DUCT, 3-WIDE-CHANNEL

For ducts not over 48 inches wide by 24 inches high, 2-inch wide by 1 1/2-inch channels, spaced not more than 4 feet apart may be installed. The total extension of the hanger supports shall not exceed 6 inches.

Hanger design and spacing for fibrous glass ducts is based upon extensive testing with loads exceeding twice the duct weight located between supports to assure the integrity of the duct system. Recommended hanger spacing is shown in Figure No. 10-5-28. Caution should be taken with other types of hanger systems to assure that excessive stress is not placed on the hanger or the fibrous glass duct system.

(d) **Fittings.** Proper support of duct fittings may require that additional hangers be installed.

For an elbow, hangers should be on each leg, within 12 inches of the throat. If the width of the duct is greater than 18 inches an additional hanger must be installed (see Figure No. 10-5-29) so that dimension *D* is approximately two thirds of the diagonal distance from throat to heel.

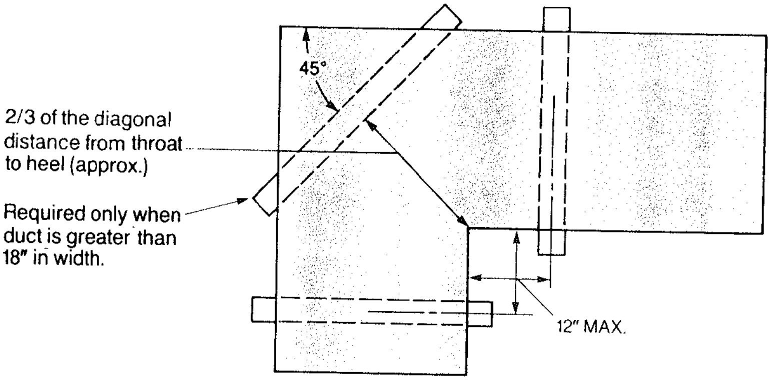

45°
2/3 of the diagonal distance from throat to heel (approx.)
Required only when duct is greater than 18" in width.
12" MAX.

FIGURE NO. 10-5-29—ELBOW SUPPORT

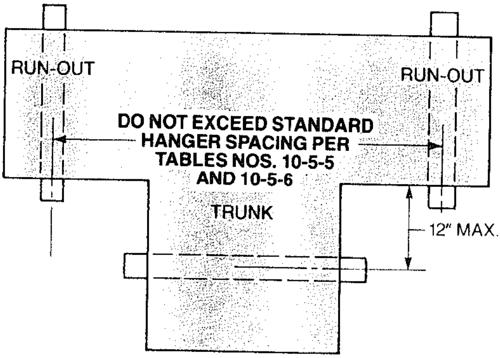

RUN-OUT
RUN-OUT
DO NOT EXCEED STANDARD HANGER SPACING PER TABLES NOS. 10-5-5 AND 10-5-6
TRUNK
12" MAX.

FIGURE NO. 10-5-30—TEE SUPPORT

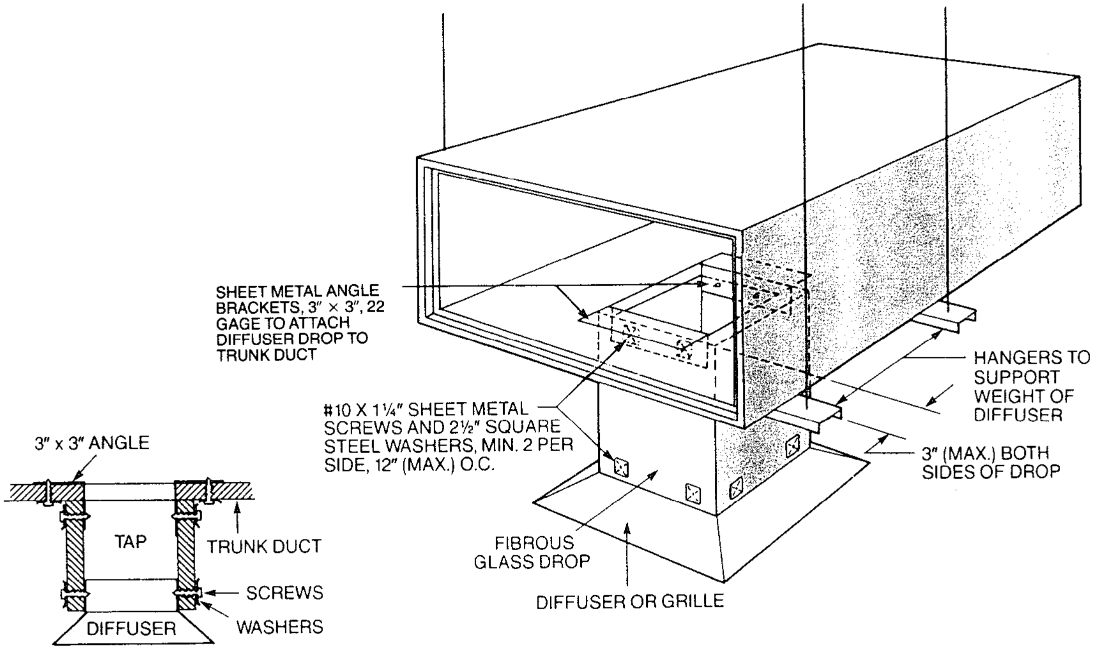

SHEET METAL ANGLE BRACKETS, 3″ × 3″, 22 GAGE TO ATTACH DIFFUSER DROP TO TRUNK DUCT
#10 X 1¼″ SHEET METAL SCREWS AND 2½″ SQUARE STEEL WASHERS, MIN. 2 PER SIDE, 12″ (MAX.) O.C.
HANGERS TO SUPPORT WEIGHT OF DIFFUSER
3″ (MAX.) BOTH SIDES OF DROP
FIBROUS GLASS DROP
DIFFUSER OR GRILLE
3″ x 3″ ANGLE
TAP
TRUNK DUCT
SCREWS
WASHERS
DIFFUSER

FIGURE NO. 10-5-31—DIFFUSER CONNECTION

Tees require support on the trunk as shown in Figure No. 10-5-30. If a tee run-out hanger falls where the trunk duct is located, add hangers on either side of trunk. Do not exceed maximum hanger spacing.

Branch ducts are treated in a similar manner with hanger spacing on the trunk duct in accordance with Figure No. 10-5-28.

For diffuser drops, hangers are installed within 3 inches of each side of the drop. The connection of the drop to the duct is reinforced in accordance with Figure No. 10-5-31.

If the drop assembly, including the diffuser, weighs more than 25 pounds, the diffuser must be separately supported.

(e) **Hanging Rigid Round Duct.** Preformed round fibrous glass duct should be hung so the hanger will not damage the duct facing.

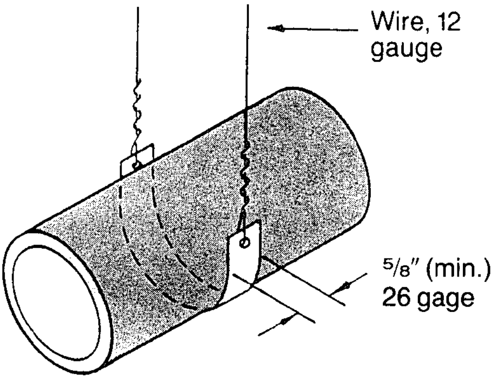


FIGURE NO. 10-5-32—HANGING ROUND DUCT WITH SADDLE AND 12 GAUGE WIRES

Straps or saddles in contact with the duct must be not less than 5/8 inch wide. Avoid sharp edges and burrs.

Space hangers at a maximum of 6 feet on center. Where practical, hangers should be located at circumferential joints. Provide hanger support at all fittings.

Part B—Flexible Ducts

Suitable Installations

Sec. 10.507. (a) **General** 1. The routing and length of flexible duct, the number of bends, the number of degrees of each bend and the amount of sag allowed between support joints will have serious effects on system performance due to the increased resistance each introduces. Use the minimum length of flexible duct to make connections. It is not recommended that excess lengths of ducts be installed to allow for possible future relocations of air terminal devices.

2. Avoid installations where exposure to direct or indirect sunlight can occur, e.g., turbine vents, skylights, canopy windows, etc. Prolonged exposure to sunlight will cause degradation of the vapor barrier.

3. Terminal devices shall be supported independently of the flexible duct.

4. Repair torn or damaged vapor barrier jacket with approved duct tape. If internal core is penetrated, replace flexible duct or treat as a connection.

(b) **Installation.** 1. Install duct fully extended, do not install in the compressed state or use excess lengths. This will noticeably increase friction losses.

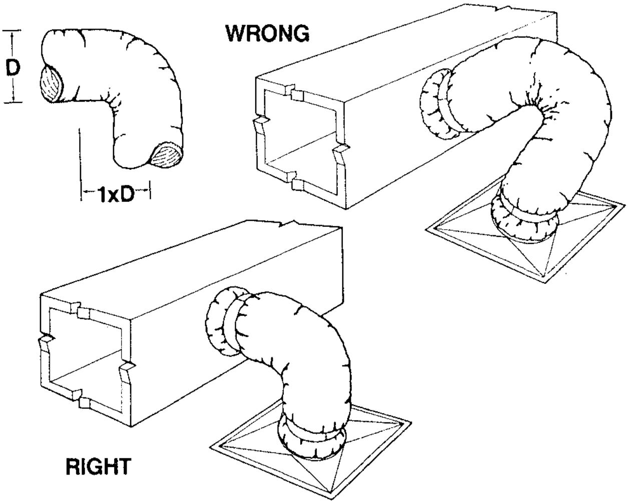


FIGURE NO. 10-5-33—EXTEND DUCT FULLY

2. Avoid bending ducts across sharp corners or incidental contact with metal fixtures pipes or conduits. Radius at center line shall not be less than one duct diameter.

3. Do not install near hot equipment (e.g., furnaces, boilers, steam pipes, etc.) that is above the recommended flexible duct use temperature.

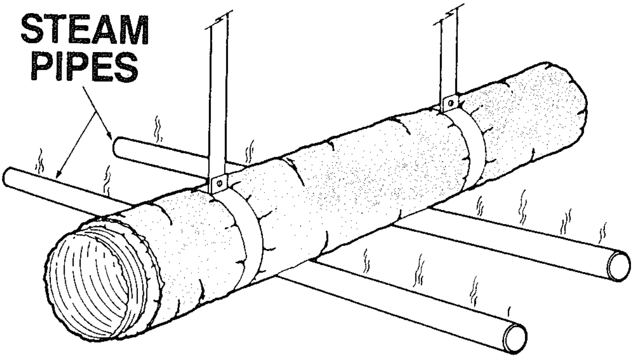


FIGURE NO. 10-5-34—WRONG METHOD OF SUPPORT

Connecting, Joining and Splicing Flexible Duct

Sec. 10.508. 1. All connections, joints and splices shall be made in accordance with the manufacturer's installation instructions.

2. Unless specified by the manufacturer, adhesives are not recommended for use with nonmetallic flexible duct as they will chemically react with the duct materials, causing deterioration and degradation.

3. Sheet metal collars to which the flexible ducts are attached shall be a minimum of 2 inches in length.

4. Sheet metal sleeves used for joining two sections of flexible duct shall be a minimum of 4 inches in length.

Installation Instructions
Nonmetallic Air Ducts with Plain Ends

(a) **Connections.** 1. After desired length is determined, cut completely around and through duct with knife. Cut wire with snips or side cutters.

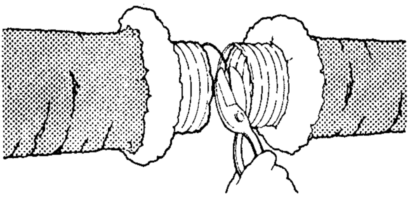


FIGURE NO. 10-5-35A—END CONNECTORS

2. Pull back jacket and insulation from core. Slide at least 1 inch of core over collar, pipe or fitting. Tape with at least 2 wraps of approved duct tape. Secure with approved clamp.

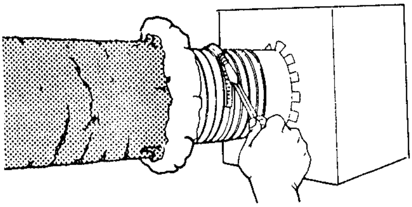


FIGURE NO. 10-5-35B

3. Pull jacket and insulation back over core. Tape jacket with two wraps of approved tape. An approved clamp may be used in place of or in conjunction with duct tape.

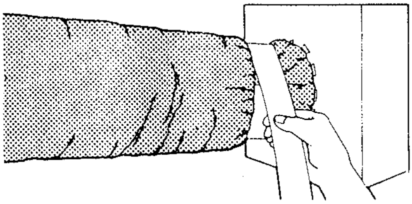


FIGURE NO. 10-5-35C

(b) **Splices.** 1. Peel back jacket and insulation from core. Butt two cores together on a minimum 4-inch-wide collar.

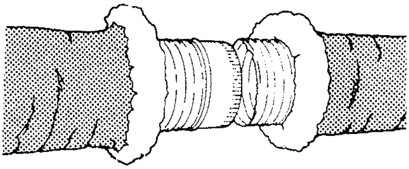


FIGURE NO. 10-5-36A—SPLICING

2. Tape together with at least two wraps of approved duct tape. Secure with two approved clamps.

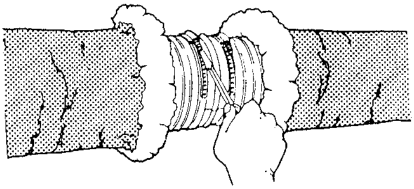


FIGURE NO. 10-5-36B

3. Pull jacket and insulation back over cores. Tape jackets together with two wraps of approved duct tape.

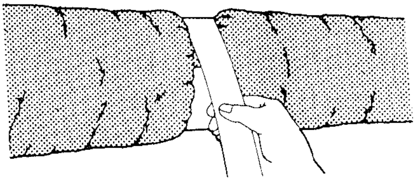


FIGURE NO. 10-5-36C

(Notes: a. For uninsulated duct/connector, disregard reference to insulation and jacket.

b. See manufacturer's installation instructions for approved tapes and clamps.

c. Use beaded fittings for pressures exceeding 4 inches W.G. and for diameters 12 inches and larger.)

Supporting Flexible Duct

Sec. 10.509. (a) Flexible duct shall be supported at manufacturer's recommended intervals, but at no greater distance than four feet. Maximum permissible sag is 1/2 inch per foot of spacing between supports.

A connection to rigid ducting or equipment shall be considered a support joint.

Long horizontal duct runs with sharp bends shall have additional supports before and after the bend approximately one duct diameter distance from the center line of the bend.

(b) Hanger or saddle material in contact with the flexible duct shall be of sufficient width to prevent any restriction of the internal diameter of the duct when the weight of the supported section rests on the hanger or saddle material. In no case will the material contacting the flexible duct be less than 1 1/2 inches wide.

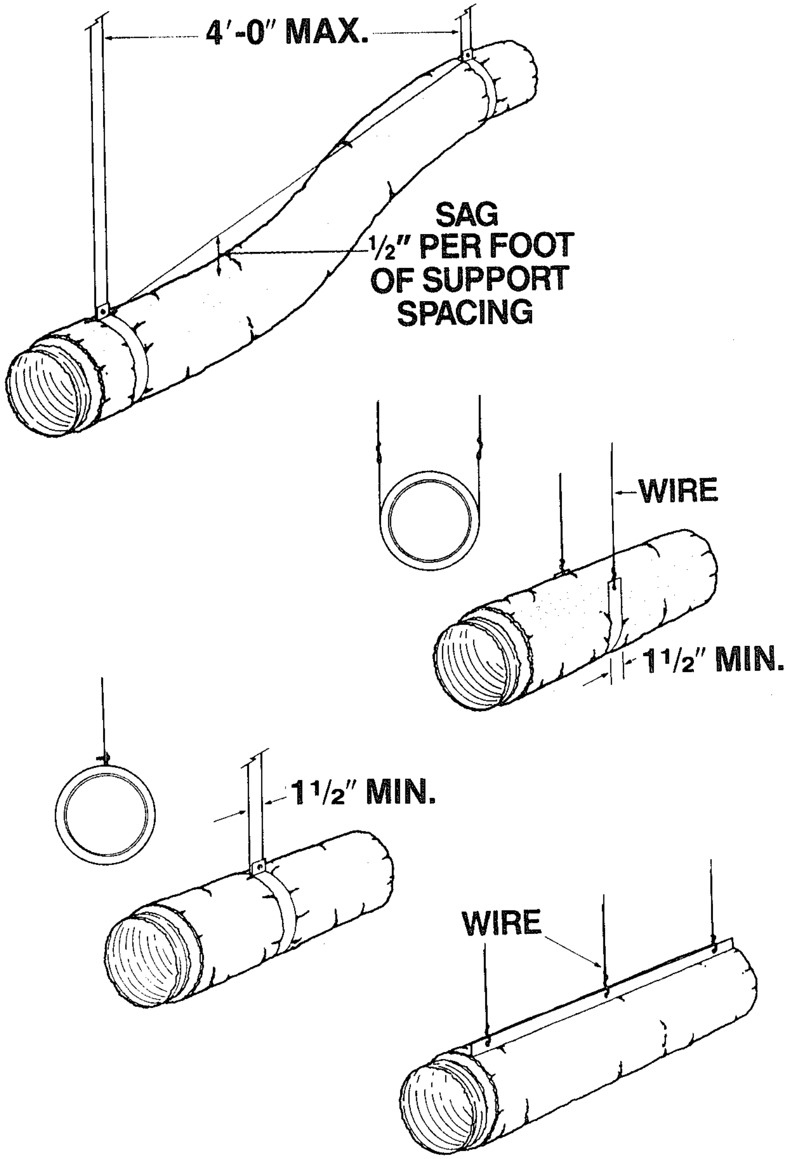


FIGURE NO. 10-5-37

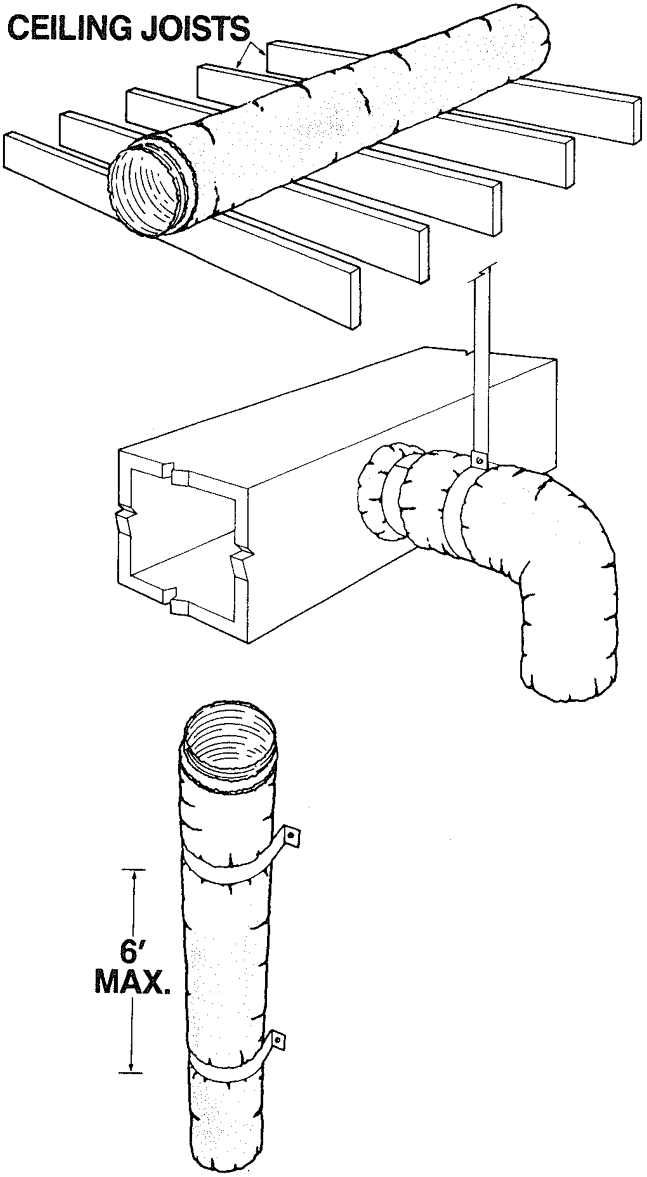


FIGURE NO. 10-5-38—PROPER SUPPORT

(c) Factory-installed suspension systems integral to the flexible duct are an acceptable alternative hanging method when manufacturer's recommended procedures are followed.

(d) Flexible ducts may rest on ceiling joists or truss supports. A maximum spacing between supports shall not exceed the maximum spacing per manufacturer's installation instructions.

(e) Support the duct between a metal connection and a bend by allowing the duct to extend straight for a few inches before making the bend. This will avoid possible damage of the flexible duct by the edge of the sheet metal collar.

(f) Vertically installed duct shall be stabilized by support straps at a maximum of 6 feet on center.

[Note: Factory-made air ducts may not be used for vertical risers in air duct systems serving more than two stories. See U.M.C. Section 1004 (b).]

Checklist

Sec. 10.510. The following checklist is provided for the benefit of the inspector, as well as the installer. It is designed so that the correct answer to all questions is yes.

General		**Yes**	**No**
________	Have all tears or punctures to facing material been repaired using the proper technique?	( )	( )
________	Are all sheet metal accessory items galvanized?	( )	( )
Product			
________	Is the UL label present? (Although each board is labeled, each section may not be since there is only one label per sheet.)	( )	( )
Fabrication and Installation			
________	When metal parts are attached, are $2\frac{1}{2}$-inch (minimum) square steel washers used on 16-inch (maximum) centers?	( )	( )
________	When staples cannot be used, are 8-inch cross tabs of approved closure being used in place of staples? (Tab spacing requirements are 12 inches on center, minimum one per side.)	( )	( )
________	Are all system joints tight, free from bulges, with taped joints showing good workmanship?	( )	( )
________	Have offsets been installed so duct sections are not forced to bend around obstructions?	( )	( )
Fire Dampers: See Section 10.505			
________	Is sheet metal sleeve present? Is duct properly attached to sleeve with screws and washers 16 inches on center? (Fibrous glass ducts must not penetrate assemblies required to have a fire damper.)	( )	( )

Access Doors

________ Is installation in accordance with Section 10.504 (e) 6? ( ) ( )

Grills, Diffusers, Registers: See Section 10.506 (4)

________ Is the extra weight of the item being separately supported and not dependent on the duct alone for support? (Exception: Registers not greater than 150 square inches in area may be attached to the duct with metal channel, without other support.) ( ) ( )

Connection to Units

________ Are sheet metal screws and washers used to secure duct system to flange extensions? (Securing the duct to the unit flange without mechanical fasteners is sufficient.) ( ) ( )

Closures: See Section 10.503

________ Are all joints in the system properly sealed? ( ) ( )

________ Are closure materials of a listed type as evidenced by presence of UL instruction sheet in duct board carton, or imprinted UL 181A on the tape? ( ) ( )

________ Are there staples or cross tabs, properly spaced, on circumferential joints? ( ) ( )

________ Are all pressure-sensitive tape closures rubbed down adequately, with staples or scrim in facing clearly visible through the tape? ( ) ( )

________ If heat-sealable tape closure was used, was it applied correctly, as evidenced by dot color change? ( ) ( )

________ If glass fabric and mastic are used, is the mesh of the glass fabric completely filled with mastic? ( ) ( )

Reinforcement: See Section 10.504

________ Is reinforcement system in accordance with Section 10.504? ( ) ( )

________ Is tie-rod spacing correct according to duct span, board type and static pressure? ( ) ( )

________ Are tie-rod washers 2½ inches square? ( ) ( )

________ Do tie-rod washers have turned edges facing away from duct board so they will not cut into it? ( ) ( )

________ If tie rods reinforce a butt joint, are rods used on *both sides* of butt joint? ( ) ( )

________ Is wire termination one of those documented in Section 10.504 (b)? ( ) ( )

________ Are antisag devices used on ducts 48-inch span or greater, to support top panel of ducts? ( ) ( )

________ Are heels of tees, elbows and end caps reinforced (formed sheet metal channel, tie rod, combination)? ( ) ( )

________ When formed sheet metal channel reinforcement is used, are sheet metal gauges, dimensions and spacing correct? ( ) ( )

________ On return ducts, are sheet metal channel reinforcements attached to ducts with screws and 2$\frac{1}{2}$-inch square washers or 2-inch by 6-inch clips? ( ) ( )

Hangers and Supports: See Sections 10.506 and 10.509

________ Are hangers installed in accordance with Section 10.506? ( ) ( )

________ Are hanger designs in accordance with Table No. 10-5-6? ( ) ( )

________ Are accessories that add weight to the duct system separately supported so as not to stress the system? [See Section 10.506 (4).] ( ) ( )

________ If formed sheet metal reinforcements are used as hangers, are attachments within 6 inches of duct sides? ( ) ( )

________ Are all fittings supported by hangers? ( ) ( )

UNIFORM MECHANICAL CODE STANDARD NO. 15-1
WROUGHT-STEEL AND WROUGHT-IRON PIPE

Based on Standard B36.10-1959 of the American National Standards Institute, Inc.
See Section 1510, Uniform Mechanical Code

Scope

Sec. 15.101. This standard covers iron and steel refrigerant piping.

Material Requirements

Sec. 15.102. The material for the pipe covered by this standard shall conform to ASTM A53. See U.B.C. Standard No. 27-1 for physical properties.

Size

Sec. 15.103. The size of all pipe in this standard is identified by the nominal pipe size. Nominal size of $^1/_8$ inch to 12 inches, inclusive, is on the basis of a standardized outside diameter and the standardized weight per foot for each size of pipe.

Dimensions and Weights

Sec. 15.104. The dimensions and weights of welded and seamless steel pipe shall conform to Table No. 15-1-A.

The dimensions and weights of welded wrought-iron steel pipe shall conform to Table No. 15-1-B.

Pipe Threads

Sec. 15.105. The threads of threaded pipe shall be of an approved type. (See Pipe Threads in Reference Standards, Appendix C of this code.)

Schedule Wall Pipe

Sec. 15.106. The schedule numbers in Tables No. 15-1-A and No. 15-1-B indicate pipe of approximately uniform strength in resisting internal pressure. When the selection of wall thickness depends primarily upon capacity to resist internal pressures under given conditions, the designer shall compute the exact value of wall thickness suitable for conditions for which the pipe is required. (See Refrigeration Piping in Reference Standards, Appendix C of this code.)

TABLE NO. 15-1-A—DIMENSIONS AND WEIGHTS OF WELDED AND SEAMLESS STEEL PIPE

SIZE: NOMINAL AND (OUTSIDE DIAMETER) (Inches)	WALL THICKNESS (Inch)	PLAIN END WEIGHT Lb./Ft.	IDENTIFICATION	
			Standard X - Strong XX - Strong	Schedule Number[1]
⅛ (0.405)	.068	.24	STD	40
	.095	.31	XS	80
¼ (0.540)	.088	.42	STD	40
	.119	.54	XS	80
⅜ (0.675)	.091	.57	STD	40
	.126	.74	XS	80
½ (0.840)	.109	.85	STD	40
	.147	1.09	XS	80
	.188	1.31		160
	.294	1.71	XXS	
¾ (1.050)	.113	1.13	STD	40
	.154	1.47	XS	80
	.219	1.94		160
	.308	2.44	XXS	
1 (1.315)	.133	1.68	STD	40
	.179	2.17	XS	80
	.250	2.84		160
	.358	3.66	XXS	
1¼ (1.660)	.140	2.27	STD	40
	.191	3.00	XS	80
	.250	3.76		160
	.382	5.21	XXS	
1½ (1.900)	.145	2.72	STD	40
	.200	3.63	XS	80
	.281	4.86		160
	.400	6.41	XXS	
2 (2.375)	.154	3.65	STD	40
	.218	5.02	XS	80
	.344	7.46		160
	.436	9.03	XXS	
2½ (2.875)	.203	5.79	STD	40
	.276	7.66	XS	80
	.375	10.01		160
	.552	13.70	XXS	

TABLE NO. 15-1-A—DIMENSIONS AND WEIGHTS OF WELDED AND SEAMLESS STEEL PIPE—(Continued)

SIZE: NOMINAL AND (OUTSIDE DIAMETER) (Inches)	WALL THICKNESS (Inch)	PLAIN END WEIGHT Lb./Ft.	IDENTIFICATION	
			Standard X - Strong XX - Strong	Schedule Number[1]
3 (3.500)	.125	4.51		
	.156	5.58		
	.188	6.63		
	.216	7.58	STD	40
	.250	8.68		
	.281	9.67		
	.300	10.25	XS	80
	.438	14.31		160
	.600	18.58	XXS	
3½ (4.000)	.125	5.17		
	.156	6.41		
	.188	7.63		
	.226	9.11	STD	40
	.250	10.01		
	.281	11.17		
	.318	12.51	XS	80
4 (4.500)	.125	5.84		
	.156	7.25		
	.188	8.64		
	.219	10.00		
	.237	10.79	STD	40
	.250	11.35		
	.281	12.67		
	.312	13.98		
	.337	14.98	XS	80
	.438	18.98		120
	.531	22.52		160
	.674	27.54	XXS	
5 (5.563)	.156	9.02		
	.188	10.76		
	.219	12.49		
	.258	14.62	STD	40
	.281	15.87		
	.312	17.52		
	.344	19.16		
	.375	20.78	XS	80
	.500	27.04		120
	.625	32.96		160
	.750	38.55	XXS	

(Continued)

TABLE NO. 15-1-A—DIMENSIONS AND WEIGHTS OF WELDED AND SEAMLESS STEEL PIPE—(Continued)

SIZE: NOMINAL AND (OUTSIDE DIAMETER) (Inches)	WALL THICKNESS (Inch)	PLAIN END WEIGHT Lb./Ft.	IDENTIFICATION	
			Standard X - Strong XX - Strong	Schedule Number[1]
6 (6.625)	.188	12.89		
	.219	14.97		
	.250	17.02		
	.280	18.97	STD	40
	.312	21.07		
	.344	23.06		
	.375	25.03		
	.432	28.57	XS	80
	.562	36.42		120
	.719	45.34		160
	.864	53.16	XXS	
8 (8.625)	.188	16.90		
	.203	18.27		
	.219	19.64		
	.250	22.36		20
	.277	24.70		30
	.312	27.74		
	.322	28.55	STD	40
	.344	30.40		
	.375	33.04		
	.406	35.66		60
	.438	38.26		
	.500	43.39	XS	80
	.594	50.93		100
	.719	60.69		120
	.812	67.79		140
	.875	72.42	XXS	
	.906	74.71		160
10 (10.750)	.188	21.15		
	.203	22.88		
	.219	24.60		
	.250	28.04		20
	.279	31.20		
	.307	34.24		30
	.344	38.20		
	.365	40.48	STD	40
	.438	48.19		
	.500	54.74	XS	60
	.594	64.40		80
	.719	77.00		100
	.844	89.27		120
	1.000	104.13	XXS	140
	1.125	115.65		160

TABLE NO. 15-1-A—DIMENSIONS AND WEIGHTS OF WELDED AND SEAMLESS STEEL PIPE—(Continued)

SIZE: NOMINAL AND (OUTSIDE DIAMETER) (Inches)	WALL THICKNESS (Inch)	PLAIN END WEIGHT Lb./Ft.	IDENTIFICATION	
			Standard X - Strong XX - Strong	Schedule Number[1]
12 (12.750)	.203	27.22		
	.219	29.28		
	.250	33.38		20
	.281	37.45		
	.312	41.51		
	.330	43.77		30
	.344	45.55		
	.375	49.56	STD	
	.406	53.56		40
	.438	57.53		
	.500	65.42	XS	
	.562	73.22		60
	.688	88.57		80
	.844	107.29		100
	1.000	125.49	XXS	120
	1.125	139.68		140
	1.312	160.33		160

[1] For working pressures in excess of 300 psi use not less than Schedule 80. For 1½ inches or smaller use not less than Schedule 80 if pipe is threaded.

TABLE NO. 15-1-B—DIMENSIONS AND WEIGHTS OF WELDED WROUGHT-IRON PIPE

SIZE: NOMINAL AND (OUTSIDE DIAMETER) (Inches)	WALL THICKNESS (Inch)	PLAIN END WEIGHT Lb/Ft	IDENTIFICATION	
			Standard X - Strong XX - Strong	Schedule Number
⅛ (0.405)	.069 .096	.24 .31	STD XS	40 80
¼ (0.540)	.090 .124	.42 .54	STD XS	40 80
⅜ (0.675)	.093 .129	.57 .74	STD XS	40 80
½ (0.840)	.111 .151 .307	.85 1.09 1.71	STD XS XXS	40 80
¾ (1.050)	.115 .157 .318	1.13 1.47 2.44	STD XS XXS	40 80
1 (1.315)	.136 .183 .369	1.68 2.17 3.66	STD XS XXS	40 80
1¼ (1.660)	.143 .196 .393	2.27 3.00 5.21	STD XS XXS	40 80
1½ (1.900)	.148 .204 .411	2.72 3.63 6.41	STD XS XXS	40 80
2 (2.375)	.157 .223 .447	3.65 5.02 9.03	STD XS XXS	40 80
2½ (2.875)	.207 .282 .567	5.79 7.66 13.70	STD XS XXS	40 80
3 (3.500)	.221 .306 .615	7.58 10.25 18.58	STD XS XXS	40 80
3½ (4.000)	.231 .325 .651	9.10 12.51 22.85	STD XS XXS	40 80
4 (4.500)	.242 .344 .690	10.79 14.98 27.54	STD XS XXS	40 80
5 (5.563)	.263 .383 .768	14.61 20.78 38.55	STD XS XXS	40 80

TABLE NO. 15-1-B—DIMENSIONS AND WEIGHTS OF WELDED WROUGHT-IRON PIPE—(Continued)

SIZE: NOMINAL AND (OUTSIDE DIAMETER) (Inches)	WALL THICKNESS (Inch)	PLAIN END WEIGHT Lb/Ft	IDENTIFICATION	
			Standard X - Strong XX - Strong	Schedule Number
6 (6.625)	.286	18.97	STD	40
	.441	28.57	XS	80
	.884	53.16	XXS	
8 (8.625)	.283	24.70		30
	.329	28.55		40
	.511	43.39	XS	80
	.895	72.42	XXS	
10 (10.750)	.284	31.20		
	.313	34.24		30
	.372	40.48		40
	.510	54.74	XS	60
12 (12.750)	.336	43.77		30
	.383	49.56		
	.510	65.42	XS	

UNIFORM MECHANICAL CODE STANDARD NO. 15-2

SEAMLESS COPPER TUBE, COPPER PIPE AND RED BRASS PIPE

Based on Standard Specifications B42-62, B43-62, B68-60, B88-66, B251-66 and B280-66 of the American Society for Testing and Materials

See Section 1510, Uniform Mechanical Code

Scope

Sec. 15.201. This standard covers seamless brass and copper pipe and copper tube in all standard pipe sizes, both regular and extra strong, and seamless copper tube types DHP, DLP or OF for air conditioning and refrigeration field service; and seamless copper water tube Type K or L.

Copper tube may be bright annealed, soft coils or hard-drawn straight lengths. Annealed tube may be used with flared or compression fittings and with solder-type fittings. Drawn temper tube may be used with solder-type fittings. Type K or L tube in the drawn temper may be used with suitable type of compression fittings.

Definitions

Sec. 15.202. For the purposes of this standard, certain abbreviations, phrases and words shall be construed as specified in this section.

ACR is a seamless copper tube for air conditioning and refrigeration field service.

AVERAGE DIAMETER is the average of the maximum and minimum outside diameters or the maximum and minimum inside diameters, whichever is applicable as determined by any one cross section of the tube.

DHP is phosphorized copper, high-residual phosphorus.

DLP is phosphorized copper, low-residual phosphorus.

OF is oxygen-free copper without residual metallic deoxidants.

PIPE is seamless tube conforming to the particular dimensions commercially known as "Standard Pipe Size."

TUBE is a hollow product of round or any other cross section having a continuous periphery.

Manufacture

Sec. 15.203. (a) **General.** The material shall be of such quality and purity that the finished product shall have the properties and characteristics prescribed in this standard.

The material shall be produced by either hot or cold working operations or both. It shall be finished by such cold working and annealing or heat treatment as may be necessary to produce the required temper and surface finish.

(b) **Annealing and Temper.** Brass pipe shall be annealed sufficiently to show complete recrystallization and to enable the pipe to meet the test requirements prescribed by this standard.

Copper tube coils shall be annealed after coiling.

Types K and L tubes when in lengths and Types DLP, DHP and OF may be annealed.

(c) **Sealing.** ACR tube shall be dehydrated and sealed. Straight lengths shall be cleaned and capped, plugged or otherwise sealed.

Chemical Composition

Sec. 15.204. The material shall conform to the chemical composition shown in Table No. 15-2-A.

Mechanical Requirements

Sec. 15.205. The pipe or tube shall conform to the mechanical property requirements shown in Table No. 15-2-B.

Expansion Test

Sec. 15.206. (a) **Pipe.** Brass pipe in the annealed condition and copper pipe shall withstand an expansion of 25 percent of the inside diameter without cracking when expanded by a tapered pin having a 60-degree included angle. The expanded pipe shall show no cracking or rupture visible to the unaided eye.

(b) **Tube.** Annealed copper tubes in the annealed condition and cold-drawn tubes shall be capable of being expanded on a hardened and ground, tapered steel pin having a 60-degree included angle to the following amounts:

BRIGHT ANNEALED TYPES DLP, DHP, OF AND OUTSIDE DIAMETER (Inches)	EXPANSION OF OUTSIDE DIAMETER Percent
3/4 and under	40
over 3/4	30
WATER TUBE TYPE K OR L STANDARD SIZE (Inches)	
5/8 and under	40
over 5/8	30
AIR CONDITIONING AND REFRIGERATION FIELD SERVICE TUBE	
All sizes	40

The expanded tube shall show no cracking or rupture visible to the unaided eye.

(c) **Alternate.** A flattening test may be applied to brass or copper pipe or tube 4 inches or more in diameter as an alternate to the expansion test. For this test a 4-inch length shall be cut from the material to be tested after annealing if the material is to be annealed. This 4-inch test specimen shall be flattened so that a gage set at three times the wall thickness will pass over the pipe or tube freely throughout the flattened part. The pipe or tube so tested shall develop no cracks or flaws visible to the unaided eye. In making the flattening test, elements shall be slowly flattened by one stroke of the press.

Mercurous Nitrate Test

Sec. 15.207. Red brass pipes shall be subjected to a mercurous nitrate test.

Test specimens cut 6 inches in length shall, after proper cleaning, withstand immersion for 30 minutes without cracking in standard mercurous nitrate solution. Immediately after removal from the solution the specimen shall be wiped free of excess mercury and examined for cracks.

Bending Properties

Sec. 15.208. Annealed full sections (12 feet) of brass and copper pipe 2 inches and under shall stand being bent cold through 180 degrees around a pin the diameter of which is one and one half times the inside diameter of the pipe on the inside bent portion.

Microscopic Examination

Sec. 15.209. Copper pipe and tube shall be free from cuprous oxide as determined by microscopic examination at a 75X magnification.

EXCEPTION: Microscopic examination is not required of DHP copper.

Pressure Tests

Sec. 15.210. Samples of brass pipe and copper pipe and tube shall stand without showing weakness or defects and internal hydrostatic pressure sufficient to subject the material to a fiber stress of 7000 psi for brass and 6000 psi for copper calculated from the following formula for thin hollow cylinders under tension. Annealed pipe with wall thicknesses of up to 0.083 inch inclusive may be tested in drawn temper prior to annealing.

$$P = \frac{2St}{D-0.8t}$$

WHERE:

P = hydrostatic pressure, in pounds per square inch.

t = wall thickness, in inches.

D = outside diameter of the tube, in inches.

S = allowable stress for the material = 7000 psi for brass and 6000 psi for copper.

EXCEPTIONS: 1. For water tube Type K or L, hard drawn or annealed, less than 1/2 inch in outside diameter and less than 0.060 inch in wall thickness, the test may be made by pneumatically testing at not less than 60 psi air pressure.

2. For water tube Type K or L in coils, either of the following methods may be used:

Hydrostatically testing the tube in straight lengths as cold-drawn prior to both final coiling and annealing, or

Pneumatically testing coil or tube either before or after annealing at not less than 60 psi air pressure.

Embrittlement Test

Sec. 15.211. Samples of copper tube Types DLP, DHP or OF and copper air conditioning and refrigeration field service tube shall not show gassing or open grain structure characteristic of embrittlement when subjected to the following test:

Test specimens shall be heated to a temperature of 800° to 875°C. for a period of 20 minutes in a furnace containing an atmosphere of hydrogen. After their removal from the furnace and cleaning the specimens, if desired, the specimens shall be examined under a microscope at a magnification of 75 to 200 diameters, inclusive.

Sampling and Testing

Sec. 15.212. The method of sampling and testing shall be by an established method appropriate for the material to be tested and acceptable to the building official.

Dimensions, Weights and Tolerances

Sec. 15.213. (a) **General.** The material covered by this standard shall conform to the limiting dimensional values given in this section.

Tube shall conform to any two of the tolerances given for outside diameter, inside diameter or wall thickness.

(b) **Roundness.** Pipes and tubes of brass or copper shall conform to roundness tolerances as set forth in Table No. 15-2-C.

(c) **Tube for Air Conditioning and Refrigeration Field Service.** ACR tube shall conform to the dimensional and weight limits set forth in Tables No. 15-2-D and No. 15-2-E.

(d) **Copper Water Tube Types K and L.** Types K and L tube shall conform to the dimensional and weight limits set forth in Table No. 15-2-F.

No single tube from selected samples shall vary in weight by more than 7 percent from the theoretical weight per foot shown in Table No. 15-2-F. For the purpose of establishing the standard weight of any tube, 1 cubic inch of material is assumed to weigh 0.323 pound.

(e) **Red Brass Pipe and Copper Pipe.** Brass pipe and copper pipe shall conform to the tolerances set forth in Table No. 15-2-G.

(f) **Copper Tube Bright Annealed.** Copper tube Types DLP, DHP and OF shall conform to the tolerances set forth in Tables No. 15-2-H and No. 15-2-I.

Workmanship

Sec. 15.214. The material shall be free from any defects that would interfere with its use. It shall be well cleaned and free from dirt.

Marking

Sec. 15.215. (a) **Air Conditioning and Refrigeration Tube for Field Service.** Seamless copper tube for air conditioning or refrigeration field service shall be identified by a sticker, tag or other label attached to the package, wrapping or the tube itself.

Such tube in straight lengths shall be identified throughout its length by a blue colored marking not less than 3/16 inch in height including a legend at intervals not greater than 3 feet. The legend shall include ACR, the name or trademark, or both, and outside diameter. Other information may be included.

(b) **Water Tube.** Types K and L water tube shall be identified with the trademark or name of the manufacturer and the mark indicating the type at intervals not greater than 1 1/2 feet. Tube in straight lengths shall be identified by a colored marking not less than 3/16 inch in height including a legend repeated at intervals not greater than 3 feet. The legend shall include the type of tube, the name or trademark of the manufacturer, or both, and the country of origin. Colors are to be green for the Type K and blue for the Type L. Colors are not applicable to tubes finished in coils.

TABLE NO. 15-2-A—CHEMICAL COMPOSITION OF BRASS PIPE AND COPPER PIPE AND TUBE

PERCENTAGE OF	BRASS PIPE	COPPER PIPE	COPPER TUBE			
			K or L	DLP	DHP	OF
Copper[1] Min.	84.0	99.90	99.90	99.90	99.90	99.95
Max.	86.0	—	—	—	—	—
Phosphorous						
Min.	—	—	—	0.004	0.012	—
Max.	—	0.040	0.040	0.015	0.040	—
Lead Max.	0.06	—	—	—	—	—
Iron	0.05	—	—	—	—	—
Zinc	Remainder	—	—	—	—	—

[1] Silver containing copper.

TABLE NO. 15-2-B—MECHANICAL REQUIREMENTS OF BRASS PIPE AND COPPER PIPE AND TUBE

TYPE OF PIPE OR TUBE	TEMPER	ROCKWELL HARDNESS		TENSILE STRENGTH Min. Psi	YIELD STRENGTH Min. Psi	AVG. GRAIN SIZE m m
		Scale	Valve			
Brass Pipe	Annealed			40,000	12,000[1]	See Sec. 15.203 (b)
Copper Pipe 1/8" to 2" incl. 2 1/2" to 12" incl.	Drawn Drawn			45,000 36,000	40,000[1] 30,000[1]	— —
Copper Tube DLP, DPH, or OF	Soft Anneal Drawn			30,000[2] 36,000		.035 —
Copper Tube K or L	Annealed Coils Straight Drawn	F F 3OT	50 Max. 55 Max. 30 Min.	30,000 30,000 36,000		.040 .025 —

[1] At .05 percent extension under load.

[2] Minimum 40 percent elongation in 2 inches.

TABLE NO. 15-2-C—BRASS AND COPPER ROUNDNESS TOLERANCES

1/D (Ratio of wall thickness to nominal outside diameter)	ROUNDNESS TOLERANCE[1] percent of nominal outside diameter (Expressed to nearest 0.001 in.)
0.01 to 0.03, incl.	1.5
Over 0.03 to 0.05, incl.	1.0
Over 0.05 to 0.10, incl.	0.8 or 0.002 inch, whichever is greater
Over 0.10	0.7 or 0.002 inch, whichever is greater

[1] Roundness tolerances are not applicable to ACR annealed tubes in straight lengths or ACR tubes finished in coils.

TABLE NO. 15-2-D—ACR TUBE STANDARD DIMENSIONS AND WEIGHTS AND TOLERANCES FOR SOFT COIL LENGTHS

STANDARD SIZE (Inches)	OUTSIDE DIAMETER (Inches)	WALL THICKNESS (Inch)	WEIGHT (lb. per ft.)	TOLERANCES	
				Average Outside Diameter, plus and minus, in.	Wall Thickness, plus and minus, in.
⅛	0.125	0.030	0.0347	0.002	0.003
3/16	0.187	0.030	0.0575	0.002	0.0025
¼	0.250	0.030	0.0804	0.002	0.0025
5/16	0.312	0.032	0.109	0.002	0.0025
⅜	0.375	0.032	0.134	0.002	0.0025
½	0.500	0.032	0.182	0.002	0.0025
⅝	0.625	0.035	0.251	0.002	0.0030
¾	0.750	0.042	0.362	0.0025	0.0035
⅞	0.875	0.045	0.455	0.003	0.004
1⅛	1.125	0.050	0.655	0.0035	0.004
1⅜	1.375	0.055	0.884	0.004	0.0045

TABLE NO. 15-2-E—ACR TUBE STANDARD DIMENSIONS AND WEIGHTS AND TOLERANCES FOR STRAIGHT LENGTHS

STANDARD SIZE (Inches)	OUTSIDE DIAMETER (Inches)	WALL THICKNESS (Inch)	WEIGHT (lb. per ft.)	TOLERANCES	
				Average Outside Diameter, plus and minus, in.	Wall Thickness, plus and minus, in.
3/8	0.375	0.030	0.126	0.001	0.0035
1/2	0.500	0.035	0.198	0.001	0.0035
5/8	0.625	0.040	0.285	0.001	0.0035
3/4	0.750	0.042	0.362	0.001	0.0035
7/8	0.875	0.045	0.455	0.001	0.004
1 1/8	1.125	0.050	0.655	0.0015	0.004
1 3/8	1.375	0.055	0.884	0.0015	0.0045
1 5/8	1.625	0.060	1.14	0.002	0.0045
2 1/8	2.125	0.070	1.75	0.002	0.006
2 5/8	2.625	0.080	2.48	0.002	0.006
3 1/8	3.125	0.090	3.33	0.002	0.007
3 5/8	3.625	0.100	4.29	0.002	0.007
4 1/8	4.125	0.110	5.38	0.002	0.009

TABLE NO. 15-2-F—DIMENSIONS, WEIGHTS AND TOLERANCES IN DIAMETER AND WALL THICKNESS FOR STANDARD COPPER WATER TUBE SIZES

STANDARD SIZE (Inches)	NOMINAL OUTSIDE DIAMETER (Inches)	AVERAGE OUTSIDE DIAMETER Tolerance (Inch)		NOMINAL WALL THICKNESS AND TOLERANCES (Inch)				THEORETICAL WEIGHT (lb. per ft.)	
				TYPE K		TYPE L			
		Annealed	Drawn	Wall Thickness	Tolerance	Wall Thickness	Tolerance	Type K	Type L
1/4	0.375	0.002	0.001	0.035	0.004	0.030	0.0035	0.145	0.126
3/8	0.500	0.0025	0.001	0.049	0.004	0.035	0.0035	0.269	0.198
1/2	0.625	0.0025	0.001	0.049	0.004	0.040	0.0035	0.344	0.285
5/8	0.750	0.0025	0.001	0.049	0.004	0.042	0.0035	0.418	0.362
3/4	0.875	0.003	0.001	0.065	0.0045	0.045	0.004	0.641	0.455
1	1.125	0.0035	0.0015	0.065	0.0045	0.050	0.004	0.839	0.655
1 1/4	1.375	0.004	0.0015	0.065	0.0045	0.055	0.0045	1.04	0.884
1 1/2	1.625	0.0045	0.002	0.072	0.005	0.060	0.0045	1.36	1.14
2	2.125	0.005	0.002	0.083	0.007	0.070	0.006	2.06	1.75
2 1/2	2.625	0.005	0.002	0.095	0.007	0.080	0.006	2.93	2.48
3	3.125	0.005	0.002	0.109	0.007	0.090	0.007	4.00	3.33
3 1/2	3.625	0.005	0.002	0.120	0.008	0.100	0.007	5.12	4.29
4	4.125	0.005	0.002	0.134	0.010	0.110	0.009	6.51	5.38
5	5.125	0.005	0.002	0.160	0.010	0.125	0.010	9.67	7.61
6	6.125	0.005	0.002	0.192	0.012	0.140	0.011	13.9	10.2
8	8.125	0.006	+0.002 −0.004	0.271	0.016	0.200	0.014	25.9	19.3
10	10.125	0.008	+0.002 −0.006	0.338	0.018	0.250	0.016	40.3	30.1
12	12.125	0.008	+0.002 −0.006	0.405	0.020	0.280	0.018	57.8	40.4

NOTE: All tolerances in this table are plus and minus except as otherwise indicated.

TABLE NO. 15-2-G—DIMENSIONS AND WEIGHTS OF COPPER AND RED BRASS PIPE, STANDARD PIPE SIZES

Standard Pipe Size (Inches)	NOMINAL DIMENSIONS (Inches)			Cross-Sectional Area of Bore (sq. in.)	NOMINAL WEIGHT (lb. per ft.)	
	Outside Diameter	Inside Diameter	Wall Thickness[1]		Red Brass[1]	Copper[1]
REGULAR						
⅛	0.405	0.281	0.062	0.062	0.253	0.259
¼	0.540	0.376	0.082	0.110	0.447	0.457
⅜	0.675	0.495	0.090	0.192	0.627	0.641
½	0.840	0.626	0.107	0.307	0.934	0.955
¾	1.050	0.822	0.114	0.531	1.27	1.30
1	1.315	1.063	0.126	0.887	1.78	1.82
1¼	1.660	1.368	0.146	1.47	2.63	2.69
1½	1.900	1.600	0.150	2.01	3.13	3.20
2	2.375	2.063	0.156	3.34	4.12	4.22
2½	2.875	2.501	0.187	4.91	5.99	6.12
3	3.500	3.062	0.219	7.37	8.56	8.75
3½	4.000	3.500	0.250	9.62	11.2	11.4
4	4.500	4.000	0.250	12.6	12.7	12.9
5	5.562	5.062	0.250	20.1	15.8	16.2
6	6.625	6.125	0.250	29.5	19.0	19.4
8	8.625	8.001	0.312	50.3	30.9	31.6
10	10.750	10.020	0.365	78.8	45.2	46.2
12	12.750	12.000	0.375	113.0	55.3	56.5
EXTRA STRONG						
⅛	0.405	0.205	0.100	0.003	0.363	0.371
¼	0.540	0.294	0.123	0.068	0.611	0.625
⅜	0.675	0.421	0.127	0.139	0.829	0.847
½	0.840	0.542	0.149	0.231	1.23	1.25
¾	1.050	0.736	0.157	0.425	1.67	1.71
1	1.315	0.951	0.182	0.710	2.46	2.51
1¼	1.660	1.272	0.194	1.27	3.39	3.46
1½	1.900	1.494	0.203	1.75	4.10	4.19
2	2.375	1.933	0.221	2.94	5.67	5.80
2½	2.875	2.315	0.280	4.21	8.66	8.85
3	3.500	2.892	0.304	6.57	11.6	11.8
3½	4.000	3.358	0.321	8.86	14.1	14.4
4	4.500	3.818	0.341	11.5	16.9	17.3
5	5.562	4.812	0.375	18.2	23.2	23.7
6	6.625	5.751	0.437	26.0	32.2	32.9
8	8.625	7.625	0.500	45.7	48.4	49.5
10	10.750	9.750	0.500	74.7	61.1	62.4

[1] The wall thickness shall be not less than and the weight shall be not more or less than 5 percent for pipes 6 inches and under, 7 percent for pipes 6 to 8 inches and 8 percent for pipes over 8 inches.

TABLE NO. 15-2-H—WALL THICKNESS TOLERANCES FOR COPPER TUBE
(Applicable to ASTM Designations B68, B75 and B135.)

WALL THICKNESS (Inch)	OUTSIDE DIAMETER (Inch)						
	1/32 to 1/8 incl.	Over 1/8 to 5/8 incl.	Over 5/8 to 1, incl.	Over 1 to 2, incl.	Over 2 to 4, incl.	Over 4 to 7, incl.	Over 7 to 10, incl.
Under 0.018	0.002	0.001	0.0015	0.002	—	—	—
0.018, incl, to 0.025	0.003	0.002	0.002	0.0025	—	—	—
0.025, incl, to 0.035	0.003	0.0025	0.0025	0.003	0.004	—	—
0.035, incl, to 0.058	0.003	0.003	0.0035	0.0035	0.005	0.007	—
0.058, incl, to 0.083	—	0.0035	0.004	0.004	0.006	0.008	0.010
0.083, incl, to 0.120	—	0.004	0.005	0.005	0.007	0.009	0.011
0.120, incl, to 0.165	—	0.005	0.006	0.006	0.008	0.010	0.012
0.165, incl, to 0.220	—	0.007	0.0075	0.008	0.010	0.012	0.014
0.220, incl, to 0.284	—	—	0.009	0.010	0.012	0.014	0.016
0.284, incl, to 0.380	—	—	0.011	0.012	0.014	0.016	0.018
0.380 and over	—	—	—	5 per cent	5 per cent	6 per cent	6 per cent

NOTE: *Maximum Deviation at Any Point*: The above tolerances are plus and minus, if tolerances all plus or all minus are desired, double the values given.

TABLE NO. 15-2-I—AVERAGE DIAMETER TOLERANCES FOR COPPER TUBE

SPECIFIED DIAMETER (Inches)	DIAMETER TO WHICH TOLERANCE APPLIES	TOLERANCE, PLUS AND MINUS (Inch)
Up to ⅛, incl.	inside or outside	0.002
Over ⅛ to ⅝, incl.	inside or outside	0.002
Over ⅝ to 1, incl.	inside or outside	0.0025
Over 1 to 2, incl.	inside or outside	0.003
Over 2 to 3, incl.	inside or outside	0.004
Over 3 to 4, incl.	inside or outside	0.005
Over 4 to 5, incl.	inside or outside	0.006
Over 5 to 6, incl.	inside or outside	0.007
Over 6 to 8, incl.	inside or outside	0.008
Over 8 to 10, incl.	inside or outside	0.010

UNIFORM BUILDING CODE STANDARD NO. 43-7
FIRE DAMPERS AND CEILING DAMPERS

Test Standard of the International Conference of Building Officials

See Sections 503 (c), 1706 (b), 4306 (b) and 4306 (j), Uniform Building Code, and Sections 406 and 1006, Uniform Mechanical Code

Scope

Sec. 43.701. These requirements and methods of test apply to fire damper and ceiling damper assemblies of various materials and types of construction. As used in this standard, the term "damper assembly" applies to both fire dampers and ceiling dampers.

Tests made in conformity with these test methods will register performance during the fire test exposure; but such tests shall not be construed as determining suitability for use after exposure to fire.

Instructions

Sec. 43.702. (a) **General.** Installation shall be in accordance with the manufacturer's listing. Instructions with illustrations where appropriate shall be included for mounting in the ceiling, wall, door or floor and for joining with duct material.

(b) **Attachments.** The instructions for fire dampers shall require the use of sleeves with perimeter mounting angles attached to the sleeve on both sides of the wall or floor opening. The connecting ducts shall not be shown as continuous but shall be shown to terminate at the sleeve. The minimum thickness of sleeves shall be 0.055 inch (No. 16 gage) for dampers with dimensions not exceeding 24 inches in height nor 36 inches in width, and 0.068 inch (No. 14 gage) for larger sizes.

EXCEPTIONS: 1. Sleeves in thicknesses less than required by Section 43.702 (b) may be indicated in installation instructions when the damper and sleeve have been tested and listed in combination and provided that S-type slip joints are indicated as the means of connection between the sleeve and duct, and provided that the sleeve thickness is not less than the duct thickness required by the Uniform Mechanical Code.

2. The installation instructions for fire dampers tested and listed with integral frame and sleeve of sufficient length to permit direct attachment of perimeter mounting angles on each side of the wall or floor opening are not required to indicate the use of sleeves, provided the gage of the damper frame conforms to the requirements for sleeves.

Construction

Sec. 43.703. (a) **General.** Fire dampers shall be constructed so as to provide an effective barrier to air flow when in the closed position. In fire dampers intended for installation in ducts, the vertical through openings at the sides of the blades for operating clearance shall not exceed $^3/_8$ inch, horizontal through openings for operating clearance shall not exceed 1/32 inch. Fire dampers intended for installation in walls or floors outside of ducts shall have no vertical or horizontal through openings.

NOTE: A through opening in a fire damper is a visible opening in the face of the damper when viewed on a plane perpendicular to the mounting plane.

(b) **Binders, Adhesives, Sealants and Finishes.** Nonmetal lic or organic materials used as binders, adhesives, insulation sealants or finishes may be used if the product otherwise conforms to these requirements.

(c) **Corrosion Resistances.** Component springs and bearings used in the assembly of ceiling or fire dampers shall be of material having resistance to atmospheric corrosion equivalent to brass or bronze.

Component springs used in the assembly of a fire or ceiling damper shall be of material having spring properties equivalent to stainless steel conforming to A313.

Steel parts used in the assembly shall be provided with corrosion protection equivalent to one of the following:

1. Employing stainless steel having resistance to corrosion at least equal to one of the 300 series of stainless steels.

2. Coating of zinc capable of withstanding not less than two dips in a standard copper sulfate solution.

3. Coating of cadmium not less than 0.00050 inch thick.

4. Two coats of good quality finish of the alkyd-resin type or other type outdoor paint. The suitability of the paint may be determined by consideration of its composition or by corrosion tests.

Coated or uncoated metals used in the assembly of fire dampers shall not be used in combination such as to cause detrimental galvanic action which will adversely affect the function of any part of the assembly formed from such material.

(d) **Fusible Link or Responsive Device.** A fusible link, other temperature-responsive device, smoke or particles of combustion-responsive device shall be of an approved type.

The load on a fusible link shall not exceed the listed design load of the fusible link.

Performance

Sec. 43.704. The performance of fire and ceiling dampers shall meet the applicable requirements when tested as described herein. If any indications are observed during the tests that the product will not continue to meet the requirements in normal usage so as to assure continued safe performance, such supplementary tests shall be conducted as deemed necessary to assure safe service. Table No. 43-7-A indicates the tests applicable to the specific types of fire dampers.

TABLE NO. 43-7-A— TEST FOR FIRE DAMPERS AND CEILING DAMPERS

TESTS	FIRE DAMPERS IN OR OUTSIDE DUCTS THROUGH WALLS OR FLOORS		CEILING DAMPERS IN OPENINGS THROUGH FIRE-RESISTING CEILINGS	
	Gravity-operated	Spring-operated	Gravity-operated	Spring-operated
(1) Closing Reliability	X	X	X	X
(2) Dust Loading	X	X	X	X
(3) Salt-spray Exposure	X	X	X	X
(4) Spring Closing Force	—	X	—	X
(5) Fire Endurance	X	X	X	X
(6) Hose Stream	X	X	—	—

X = Test applicable.

— = Test not applicable.

Closing Reliability Test

Sec. 43.705. (a) **Performance.** A damper assembly shall close and latch automatically (if a latch is provided) from the open position during each of 250 operations and shall throughout this test show no evidence of undue wear, distortion, displacement or rupture of its parts.

(b) **Selecting and Positioning Samples.** Samples representative of the largest and smallest size, style and arrangement of damper assembly shall be subjected to this test. Damper assemblies intended for horizontal installation shall be tested in a horizontal plane and not depend on installation in an inclined position for proper operation.

Dust Loading Test

Sec. 43.706. (a) **Performance.** A damper assembly shall close and latch automatically (if latch is provided) from the open position following exposure for seven hours to an air-blown circulating grain-dust air mixture. The grain dust shall pass through a 100-mesh screen.

(b) **Selecting and Positioning Sample.** Samples representative of each style and arrangement of damper assembly supported in the position of its intended use shall be tested in a specially constructed test chamber approximately 5 by 7 1/2 by 5 feet high, provided with observation windows and with auxiliary equipment to produce a circulating grain-dust-air mixture. Nozzles shall be provided to direct the dust-air mixture toward the sample, and the dust particles shall be allowed to accumulate on the various parts of the damper assembly.

Salt-spray Exposure Test

Sec. 43.707. (a) **Performance.** A damper assembly shall close and latch automatically (if a latch is provided) following exposure for a period of five days to salt spray when tested in accordance with this section.

(b) **Selecting and Preparing Sample.** A representative sample of each style and arrangement of damper assembly shall be used for the salt-spray exposure test. Prior to test, all grease or oil shall be removed from the test sample, using organic solvents.

(c) **Positioning of Sample.** The test sample shall be installed in the test chamber with the damper open and supported in the position of its intended use and exposed to the salt spray for a period of five days (120 hours). The temperature of the sample and the test chamber shall be maintained at 95°F. plus 2°F. or minus 3°F. throughout the test period.

(d) **Test Equipment.** The apparatus to be used for salt-spray (fog) testing shall consist of a fog chamber having a salt solution reservoir, a supply of suitably conditioned compressed air, a dispersion tower for producing a salt fog, specimen supports, provision for heating the chamber, and necessary means of control. The dispersion tower shall be located in the center of the chamber and shall be supplied with salt solution and with warmed, humidified air at a pressure of 17 to 19 pounds per square inch so as to disperse the salt solution in the form of a fine mist or fog throughout the interior of the chamber.

(e) **Salt Solution.** The salt solution shall consist of 20 percent by weight of common salt (sodium chloride) and distilled water. The pH value of this solution as collected after spraying in the test apparatus shall be between 6.5 and 7.2 and the specific gravity between 1.126 and 1.157 at 95°F.

(f) **Efficiency.** At the conclusion of the salt-spray exposure, the test sample shall be removed from the chamber and allowed to dry for 24 hours at room temperature. It shall then be placed in its normal mounting position and on release shall close and latch automatically (if latch is provided).

Spring Closing Force Test

Sec. 43.708. (a) **Performance.** A spring-operated damper assembly shall employ a spring or springs capable of exerting a force of two and one-half times that required to close and automatically latch (if a latch is provided) the damper.

(b) **Selecting and Positioning Sample.** A sample representative of each size, style and arrangement of damper assembly shall be subjected to this test. All springs shall be disconnected and the damper assembly placed in the intended operating position.

(c) **Measuring Force.** The force required to close and latch the damper shall be measured by appropriate means at each of a series of positions assumed by the damper from wide open to closed (latched). Force as measured shall be applied through, and at the point of connection of the spring or springs, to the damper blade or operating arm.

(d) **Efficiency.** Three samples of each spring employed for closing and latching shall be tested for force exerted over the range of extension or compression required for the motion involved in the assembly. The force available from the action of the spring or springs shall be two and one-half times that required for the closing and latching of the damper at any position of travel from wide open to latched.

Zinc Coatings

Sec. 43.709. (a) **Performance.** A protective coating of zinc shall be such that a sample of finished galvanized steel parts will not show a fixed deposit of copper after two one-minute immersions in a standard copper sulfate solution, as described below.

(b) **Test Equipment.** The apparatus consists of a large glass beaker; a chemical, all-glass, mercury thermometer; a watch or clock with a second hand; a standard solution of copper sulfate; a number of clean, dry cheesecloths; and a solvent (carbon tetrachloride or chloroform). It is essential that running tap water be available.

(c) **Copper Sulfate Solution.** The standard solution of copper sulfate which is to be used in this test is to be made up from distilled water and crystals of chemically pure copper sulfate. In a copper bottle or other suitable container made of copper, a sufficient number of the crystals is to be dissolved in hot distilled water to obtain a solution which has a specific gravity slightly higher than 1.186 after the solution has been cooled to a temperature of 65.0°F. Any free acid which may be present in the solution is to be neutralized by the addition of approximately one gram of cupric oxide (CuO) or one gram of cupric hydroxide [$Cu(OH)_2$] per liter of solution. The solution is then to be diluted with distilled water to obtain a specific gravity of exactly 1.186 at a temperature of 65.0°F. The solution is then to be filtered.

(d) **Selection of Specimen.** Several 6-inch-long specimen are to be cut and any grease, paraffin or the like is to be removed by washing the specimen in carbon tetrachloride or chloroform. Each specimen is then to be examined for evidence of damage to the zinc coating, and one which is not damaged is to be selected for use in the test.

(e) **Preparation of Specimen.** The selected specimen is to be rinsed in water and dried with a piece of clean cheesecloth. The surface of the zinc must be perfectly clean before the specimen is immersed in the solution of copper sulfate. Due care must be taken to avoid any contact between the hands or any foreign material and the cleaned surface.

(f) **Immersion of Specimen.** A glass beaker having a diameter equal to at least twice the width of the specimen is to be filled with the standard solution of copper sulfate. The temperature of the solution is to be maintained at 65.0°F. ±2.0°F. The specimen is to be immersed in the solution and supported on end in the center of the beaker so that not less than 2 1/2 inches of its length are immersed. The specimen is to remain in the solution for 60 seconds, during which time it is not to be moved nor the solution stirred.

(g) **Examination of Specimen.** At the end of the 60-second period the specimen is to be removed from the beaker, rinsed immediately in running tap water, rubbed with clean cheesecloth until any loosely adhering deposits of copper are removed, and is then to be dried with a piece of clean cheesecloth. Again, care is to be taken to avoid contact of the test surface with any foreign objects or the hands. If any part of the surface which was immersed has a bright deposit of firmly adhering metallic copper, an estimate is to be made quickly of the ratio of the area of the covered surface to the area of the total immersed surface, the portion of the specimen within 1/2 inch of the cut end or edges being disregarded.

(h) **Number of Immersions.** The immersion, washing and wiping operation just described is to be repeated successively, using the same portion of the standard solution of copper sulfate, until a bright, firmly adhering deposit of metallic copper remains on the specimen. The specimen is to be subjected to at least one more than the minimum number of such operations required for acceptable performance.

(i) **Other Specimens.** A fixed deposit of metallic copper generally occurs first at the thinnest points in the zinc coating or at those points in the zinc coating where the zinc adheres to the steel less firmly than in others. The area occupied by the fixed deposit increases upon successive dips until the entire zinc coating has disappeared. After the dips have been completed on any one specimen, the portion of the solution of copper sulfate used is to be discarded. A fresh portion of the standard solution is to be employed for each of any succeeding specimens.

(j) **Test Results.** The results are to be expressed as an estimate of the percentage of the total immersed surface (excepting the area of the 1/2-inch portion at the cut end or edges) which shows a fixed deposit of copper after each dip, i.e., after the specimen has been dipped, washed, rubbed, dried and then examined. Failure is to be recorded for any part from which a specimen shows a fixed deposit of copper as the result of a number of dips equal to or less than the required number stated in Section 43.709 (a).

Cadmium Coatings

Sec. 43.710. (a) **Minimum Thickness.** The thickness of a cadmium coating on the steel parts shall be not less than 0.00050 inch when determined by the chromic-acid dropping test, conducted as described in this section.

(b) **Chromic-acid Solution.** The solution to be used for the chromic-acid dropping test is to be made from distilled water and is to contain 200 grams per liter of chemically pure chromic acid, CrO_3, and 50 grams per liter of chemically pure concentrated sulfuric acid, H_2SO_4 (The latter is equivalent to 27 milliliters per liter of chemically pure concentrated sulfuric acid, specific gravity 1.84, containing 96 percent of H_2SO_4.)

(c) **Test Equipment.** The test solution is to be contained in a glass vessel such as a separatory funnel with the outlet equipped with a stopcock and a capillary tube of approximately 0.025-inch inside bore and 5.5 inches long. The lower end of the capillary tube is tapered to form a tip, the drops from which are about 0.05 milliliter each. To preserve an effectively constant level, a small glass tube is inserted in the top of the funnel through a rubber stopper and its position is to be adjusted so that, when the stopcock is open, the rate of dropping is 100 ± 5 drops per minute. If desired, an additional stopcock may be used in place of the glass tube to control the rate of dropping.

(d) **Solution Temperature.** The sample and the test solution should be kept in the test room long enough to acquire the temperature of the room, which should be noted and recorded. The test is to be conducted at a room temperature between 65° and 95°F.

(e) **Preparation of Sample.** Each sample is to be thoroughly cleaned before testing. All grease and other nonmetallic coatings are to be removed completely by means of suitable solvents. Samples are then to be thoroughly rinsed in water and dried with clean cheesecloth. Care should be exercised to avoid contact of the cleaned surface with the hands or any foreign material.

(f) **Positioning Sample.** The sample to be tested is to be supported from 0.7 to 1 inch below the orifice so that the drops of solution strike the point to be tested and run off quickly. The surface to be tested should be inclined about 45 degrees from horizontal.

(g) **Testing.** After cleaning, the sample to be tested is to be put in place under the orifice. The stopcock is to be opened and the time in seconds is to be measured with a stop watch until the dropping solution dissolves off the protective metallic coating, exposing the base metal. The end point is the first appearance of the base metal recognizable by the change in color at that point.

(h) **Number of Tests.** Each sample of a test lot is to be subjected to the test at three or more points, excluding cut edges and threaded surfaces.

(i) **Test Results.** If the time required for dissolving off the cadmium coating in the test is not less than that given in the following table, corresponding to the room temperature, the thickness of the coating is considered to comply with the requirement of Section 43.710 (a).

TEMPERATURE IN DEGREES FAHRENHEIT	TIME IN SECONDS
65	12
70	11
75	11
80	10
85	10
90	10
95	9

Fire-endurance Tests

Sec. 43.711. (a) **Test Assemblies.** The construction, materials and size of the test fire damper assembly, consisting of single dampers or single dampers installed in a multiple assembly, shall be representative of that for which the damper assembly is to be classified or rated. The size and dimensions of the test specimen and the exposure specified herein are intended to apply for rating of fire damper assemblies within the usual range employed in buildings. The testing agency may, at its discretion, require changes in the proposed installation when, in its judgment, such changes are necessary to obtain representative information on the performance of the construction under test or when the proposed installation is not representative of those applied in building construction.

(b) **Test Installation, Fire Dampers in Ducts, Walls or Floors.** Each test fire damper assembly shall be installed on a large-scale furnace in its intended position. If the conditions of use limit the fire damper assembly to smaller dimensions, a proportionate reduction may be made in the dimensions of the fire damper test specimen for a test qualifying them for such restricted use. Such test fire damper assembly shall be installed on a half-scale (or larger) furnace in its intended position.

Fire dampers intended for use in ducts shall be installed in a sleeve extending not more than 3 inches into the furnace. Fire dampers intended for installation in partitions or walls outside of ducts shall be installed in a frame. For a single fire damper, a sample damper shall be installed with the upstream side facing the furnace. An additional sample shall be installed with the downstream side facing the furnace. If multiple assemblies are tested at one time, the upstream sides of half the individual dampers and the downstream sides of the other half of the dampers shall face the furnace.

1. **Wall or floor clearances.** Clearances between the fire damper assembly installed in their sleeves and the wall or floor opening shall be such that the lap of the mounting angles on the wall or floor assembly is not less than 1 inch. The installation of the test fire dampers assembly shall otherwise be made in accordance with the manufacturer's installation instructions.

2. **Masonry or concrete settings.** Masonry settings shall be allowed to season at least three days before fire test. Concrete settings shall be allowed to season at least 28 days before fire test.

(c) **Test Installation, Ceiling Dampers in Fire-resisting Ceilings.** Test specimen ceiling dampers shall be installed in a fire-resisting ceiling-floor assembly on a horizontal large-scale furnace. The area of the ceiling exposed to fire shall be not less than 180 square feet, with neither dimension less than 12 feet. Fire exposure shall be to the underside of the construction.

The ceiling-floor assembly shall be representative of the type of construction (combustible, noncombustible) and the fire-endurance time period for which classification is desired, as to materials, workmanship and details such as dimensions of parts, and shall be representative of those applied in building construction and operation.

The number and area of individual fire dampers installed in each 100 square feet of ceiling area shall be representative of that for which the damper assembly is to be classified or rated.

Test specimen ceiling dampers in fire-resisting ceilings shall be mounted in the bottom of the air duct section over the air outlet or in the throat of the air duct outlet drop with support from the construction above. Subject to the provisions of Section 43.711 (a), the installation shall be made in accordance with the manufacturer's proposed installation instructions. Insulation around the duct, if any, or insulation around the air outlet duct drop shall be in accordance with the fire damper manufacturer's proposed installation instructions.

The thermocouples, their placement and temperature readings shall conform to "Fire Tests of Building Construction and Materials." Thermocouples shall be placed on structural elements (beams, girders, joists and trusses) as specified.

(d) **Alternate Test Installation, Ceiling Dampers in Fire-resisting Ceilings.** Test specimen ceiling dampers shall be installed in a fire-resisting ceiling assembly on a horizontal small-scale furnace in its intended position. The net ceiling area exposed to fire shall be not less than 40 square feet, with no dimension less than 5 feet.

1. **Representative assembly.** The assembly shall be representative of an assembly which has been tested in the horizontal large-scale furnace and for which a detailed test report containing temperature readings on the unexposed surface and structural framing members has been issued.

2. **Area.** The area of the ceiling damper shall be the maximum area for which the fire damper is to be classified.

3. **Installing test specimen.** The test specimen ceiling damper shall be installed in a representative ceiling-floor or ceiling-roof assembly as indicated in Section 43.711 (b) 1. The minimum width of exposed ceiling area on two sides of the test specimen shall be not less than 12 inches with a minimum width of exposed ceiling area on the opposite sides of not less than 6 inches. The test specimen ceiling damper shall be mounted in the bottom of a representative duct system over the air outlet or in the throat of the air duct outlet drop with support from the constructions above. Subject to the provisions of Section 43.711 (a), the installation shall be made in accordance with the manufacturer's instructions. Insulation around the duct, if any, or insulation around the air outlet duct drop shall be in accordance with the ceiling damper manufacturer's proposed installation instructions.

4. **Thermocouple placement.** Temperature readings shall be taken on the unexposed surface, in the plenum space, on the underside of the floor or roof deck and on structural members when structural members are contained in the construction. Thermocouples, their placement, and temperature readings shall conform to "Fire Tests of Building Construction and Materials."

(e) **Exposure Period.** The fire test shall be continued until the exposure period for which the damper assembly is to be rated is reached, or until the assembly fails to conform with the conditions of acceptance specified in Section 43.713. The exposure period for which the assembly is to be rated shall be determined by test as being either 45 minutes, one hour, one and one half hours, two hours or three hours.

Hose Stream Test

Sec. 43.712. (a) **Application.** Immediately following the fire exposure portion of the test for fire dampers, the fire damper test assembly shall be subjected to the impact, erosion and cooling effects of a hose stream directed first at the middle and then at all parts of the exposed surface of the damper assembly, with changes in direction of the hose stream being made slowly.

(b) **Time.** The hose stream shall be delivered through a 2½-inch hose discharging through a national standard playpipe of corresponding size equipped with a 1⅛-inch discharge tip of the standard-taper smoothbore pattern without shoulder at the orifice. The water pressure at the base of the nozzle and duration of application in minutes per 100 square feet of exposed area of the damper assembly shall be as given in Table No. 43-7-B.

TABLE NO. 43-7-B—HOSE STREAM TEST

FIRE EXPOSURE PERIOD	WATER PRESSURE AT BASE OF NOZZLE psi	DURATION OF APPLICATION, MINUTES PER 100 SQUARE FEET EXPOSED AREA
3-Hour	45	5
1 1/2-Hour and over if less than 3-Hour	30	2 1/2
1-Hour and over if less than 1 1/2-Hour	30	1 1/2

(c) **Distance.** The tip of the nozzle shall be located 20 feet from and on a line normal to the center of the test assembly. If impossible to be so located, the nozzle may be on a line deviating not more than 30 degrees from the line normal to the center of the assembly. When so located, the distance from the center shall be less than 20 feet by an amount equal to 1 foot for each 10 degrees of deviation from the normal.

Conditions of Acceptance

Sec. 43.713. (a) **Fire Dampers in Duct Systems Passing through Walls or Floors.** Fire dampers in duct systems passing through walls or floors shall be as follows:

1. A damper shall remain in the opening during the fire-endurance test for the fire exposure period for which it is to be rated and for the hose stream test.

2. All dampers in the test assembly shall close and latch automatically (if a latch is provided) during the first 60 seconds of the fire-endurance portion of the test or before the furnace temperature at the fusible element location reaches 285°F., whichever occurs first. (The temperature on the standard time-temperature curve at one minute is 285°F.)

3. During the fire and hose stream test, the movement or warping of any part of the damper assembly shall not result in a visible through opening when viewed on a plane perpendicular to the mounting plane.

4. During the fire-endurance and hose stream test, movement or warping of any part of the damper assembly shall not result in through openings between individual parts greater than 3/4 inch during the fire-endurance portion of the test, and greater than 1 inch during the hose stream portion of the test.

5. Through openings at the sides of multiblade dampers provided for operating clearances shall not increase in width during the fire-endurance and hose stream tests.

6. Latching mechanisms, blade shafts in their bearings, interlocking-type damper blades with relation to their guides, and blade guides shall remain engaged and secure during the fire-endurance and hose stream test.

(b) **Fire Dampers in Doors, Walls or Floors outside of Ducts.** Fire dampers in doors, walls or floors outside of ducts shall be as follows:

1. A damper assembly shall remain in the opening during the fire-endurance test for the fire-exposure period for which it is to be rated and for the hose stream test.

2. All dampers in the test assembly shall close and latch automatically (if a latch is provided) during the first 60 seconds of the fire-endurance portion of the test or before the furnace temperature at the fusible element location reaches 285°F., whichever occurs first. (The temperature on the standard time-temperature curve at one minute is 285°F.)

3. During the fire-endurance and hose stream test, the movement or warping of any part of the damper assembly shall not result in a visible through opening when viewed on a plane perpendicular to the mounting plane.

4. During the fire-endurance test, movement or warping of any part of the damper assembly shall not result in visible through openings between individual parts, at the sides or around the blades as viewed in any direction.

5. During the hose stream test, the movement or warping of any part of the damper assembly shall not result in through openings between individual parts as viewed in any direction greater than the width of blade lap on each other or on blade stops during the first one half of the classification but shall in no case exceed one and one-half times the width of the blade lap on each other or on the blade stops.

6. Latching mechanisms, blade shafts in their bearings, interlocking-type damper blades with relation to their guides, and blade guides shall remain engaged and secure during the fire exposure and hose stream test.

(c) **Ceiling Dampers in Fire-resisting Ceilings.** The ceiling-floor assembly tested in the horizontal large-scale furnace, may be rated for fire endurance in accordance with conditions of acceptance set forth in U.B.C. Standard No. 43-1.

(d) **Ceiling Dampers in Fire-resisting Ceilings, Alternate Test Method.** Classification of fire damper assemblies for use in fire-resisting ceilings tested in the horizontal small-scale furnace shall be in accordance with the following:

1. The ceiling damper assembly, or assemblies, in its frame shall remain in the ceiling opening during the fire-endurance test for the fire-exposure period for which it is to be rated. Openings in the ceiling assembly shall not result in greater distortion or warping of components or larger through openings than in the ceiling-floor assembly tested without openings.

2. Transmission of heat through the ceiling-floor assembly during the fire-endurance test shall not have been such as to raise the average temperature on its unexposed surface more than 250°F. above its initial temperature nor more than 325°F. at any point.

3. The average temperature of three thermocouples on the bottom surface of the wood members (2 by 10 joist at 16 inches on center shall be employed) shall not exceed 600°F. at 30 minutes or 1200°F. at 55 minutes.

4. The average temperature on any section of structural steel or reinforcing steel shall not exceed 1100°F. and the maximum temperature at any point shall not exceed 1300°F.

5. The average temperature shall not exceed 800°F. on cold-drawn prestressing steel.

Marking

Sec. 43.714. (a) **Label.** Fire and ceiling damper assemblies shall bear a label issued by an approved listing agency or a label showing the fire-protection rating of the assembly. The label shall be of metal attached to the assembly by welding or brazing or shall be a metallized label attached to the assembly with contact adhesive.

(b) **Label Markings.** The markings on the label shall include the following:

1. Name and address of the listee.
2. Model number or type.
3. Symbol, serial or issue number issued by the listing agency.
4. Rating of three, one and one-half, one or three-fourths hour indicating duration of exposure to fire.
5. The words "duct," "wall," "floor" or "ceiling" following the hourly rating designating the location for which the assembly is designed.

UNIFORM BUILDING CODE STANDARD NO. 43-12
SMOKE DAMPERS

Based on Standard for Leakage-rated Damper for Use in Smoke-control Systems 555S, September 14, 1983, of Underwriters Laboratories Inc.

See Sections 802 (b) 2, 1002 (b) and 4309, Uniform Building Code

General

Sec. 43.1201. (a) **Scope.** These requirements cover leakage-rated dampers intended for use in heating, ventilating and air-conditioning (HVAC) systems. Leakage-rated dampers are intended (1) to restrict the spread of smoke in HVAC systems that are designed to be automatically shut down in the event of a fire or (2) to control the movement of smoke within a building when the HVAC system is operational in engineered smoke-control systems.

(b) **General.** A component of a product covered by this standard shall comply with the requirements for that component and shall be used in accordance with its recognized rating and other limitations of use.

Installation and Operating Instructions

Sec. 43.1202. Installation and operating instructions shall be shipped with each damper by the manufacturer. Instructions shall be illustrated and shall include detailed directions and information adequate for the intended installation and operation of the product. Instructions shall cover mounting, sealing, wiring, opening and closing torque requirements, and duct-joining methods, if applicable, and shall be in accordance with the Mechanical Code.

The instructions are to be used as a guide in the examination and test of the product. A printed edition is required upon successful completion of the test program.

The instructions shall include recommended means of sealing the damper to ductwork or damper frame, or both.

Materials

Sec. 43.1203. (a) **General.** All electrical components, damper operators/actuators, fusible links and temperature-responsive devices shall be examined and tested as required for their intended function. Test methods shall be approved methods.

(b) **Corrosion Protection.** A ferrous metal part used in the damper assembly shall be one of the 300 Series of stainless steel or shall be provided with one of the following corrosion-protection systems:

1. A coating of hot-dipped mill-galvanized sheet steel complying with the coating designation G60 or A60 by the hot-dip process, with not less than 40 percent of the zinc on any side, based on the minimum single-spot test requirement.

2. A zinc coating, other than that provided on hot-dipped mill-galvanized sheet steel, uniformly applied to an average thickness of not less than 0.00041 inch on each surface with a minimum thickness of 0.00034 inch.
3. A cadmium coating not less than 0.0005 inch thick on both surfaces.
4. Two coats of an organic finish of the epoxy or alkyd-resin type or other outdoor paint on each surface. The acceptability of the paint may be determined by its composition or by corrosion tests.

Coated or uncoated metals used in the assembly of dampers shall be galvanically compatible.

Component springs and bearings used in the assembly of dampers shall be of material having resistance to atmospheric corrosion equivalent to brass or bronze.

A hot-dipped mill-galvanized A60 (alloyed) coating or an annealed zinc coating that is bent or similarly formed after annealing, including extruded and rolled edges and holes, and that is not otherwise required to be painted, shall be painted in the bent or formed area if the bending or forming process damages the zinc coating. If flaking or cracking of the zinc coating at the outside radius of the bent or formed section is visible at 25 power magnification, the zinc coating is to be considered damaged. Simple sheared or cut edges and punched holes are not considered to be formed.

Performance

Sec. 43.1204. (a) **General.** Three samples representative of each design or design variation, including all operational components, are to be subjected to the tests set forth in this section. The representative samples, which are intended to cover a range of damper sizes for one specific design, are to consist of (1) minimum width and maximum height, (2) maximum width and minimum height, and (3) maximum width and maximum height. In addition, two dampers, consisting of the largest and smallest sizes, are to be subjected first to the dust-loading test and then to the salt-spray test. As an option, two dampers may be subjected to the dust loading test and two additional dampers subjected independently to the salt-spray exposure test. Any component variations within the design size range may require additional samples and tests.

Both the dust-loading exposure test, Section 43.1204 (f), and the salt-spray exposure test, Section 43.1204 (g), are intended to simulate the dust and other debris that may accumulate on a damper mounted in a duct within a building, and investigate the performance of the damper while subjected to such accumulations.

(b) **Cycling Test.** A damper intended for use with an operator/actuator (that is, the electric, pneumatic or hydraulic device used to operate the damper) shall function as intended after being mechanically operated for 5,000 full-stroke (that is, close and reopen) operations, while using the recommended damper operator/actuator and while operating without duct-system pressure. For a damper intended for use without an operator/actuator, the number of full-stroke operations is to be 250 and the damper is to be cycled manually. All dampers are to be cycled while mounted in the position intended for installation.

(c) **Temperature Degradation/Cycling Test.** A damper (including any operator/actuator) that is recommended for temperatures other than ambient is to be subjected to this test prior to the leakage test. The selected elevated temperatures are to be in increments of 100°F., and the minimum temperature is to be 250°F.

A test damper (including any operator/actuator) previously subjected to the cycling test, Section 43.1204 (b), is to be exposed to the selected elevated temperature, ±5 percent for 30 minutes in the closed position.

After the 30-minute period and while at the selected elevated temperature, the damper shall function as intended while being operated through three complete operation cycles. A damper is to be operated mechanically, or if it is intended for use with an operator/actuator, cycled by using the operator/actuator that has also been subjected to the test temperature.

(d) **Leakage Test.** The amount of leakage measured during this test shall determine the leakage class of the damper, in accordance with the limitations in Table No. 43-12-A.

The dampers used for this test are to be those previously subjected to the cycling test, Section 43.1204 (b), and, if applicable, to the temperature degradation/cycling test, Section 43.1204 (c). Each damper is to be sealed against one face of an airflow measurement apparatus and cycled open and closed three times with its operator/actuator, or manually cycled if the damper is not intended for use with an operator/actuator. Prior to the test the manufacturer's recommended torque (plus 5, minus 0 percent) is to be applied to a damper intended for use with an operator/actuator. Ambient air then is to be supplied within the chamber at a rate required to maintain the specified test pressure differential (±5 percent) across the dampers. The resultant air leakage through the damper, corrected to standard temperature and pressure conditions, is to be determined using approved instrumentation and procedures. A damper intended for use without restriction as to the direction of airflow is to be tested on both sides.

The test pressures are to be 1.0 and 4.0 inches of water for all dampers. Extended range tests may be performed and reported at 8 inches, 12 inches, or both, of water at the request of the damper manufacturer.

There shall be no extrapolations above the maximum test pressures or beyond the minimum and maximum test sizes.

The damper area is to be determined from the nominal outside frame dimensions of the damper for an internal mounted damper and from the nominal inside frame dimensions for a flange-mounted damper.

The damper under test is to be mounted in the plane in which it is intended to be used and in accordance with the manufacturer's installation guidelines. A flange-mounted damper may be flange-mounted directly to the test chamber wall. For an internal-mounting damper, the test chamber wall is to be fitted with a short section of ductwork for mounting the damper. Ductwork is not to extend more than 9 inches beyond damper frame and is not to interfere with the test. A sealing means is to be used to avoid air leakage around ductwork or damper frame. Any mounting holes provided on the damper but not used are to be plugged if they provide a path for air leakage around the damper.

(e) **Operation Test.** Following completion of the leakage test, Section 43.1204 (d), and under conditions of maximum recommended airflow, the dampers shall function as intended without damage to the dampers or their components and shall completely close during each of three opening and closing cycles. The test pressure differential created in the closed position is to be recorded and shall be not less than the leakage classification rating (that is, 4, 8 or 12 inches of water). See Table No. 43-12-A. The instrumentation and procedures for all types of dampers are to be in accordance with approved standards.

The device under test is to be mounted as intended. The airflow direction is to be in the direction of normal flow through the device. If normal flow can be in either direction, and if the device reacts differently when flow is in one direction than it does when flow is in the opposite direction, the device is to be tested with the flow first in one direction, then in the other direction.

A damper intended for use with an operator/actuator is to be opened and closed by using the recommended operator/actuator. A damper not intended for use with an operator/actuator shall be manually closed using the intended releasing device and manually reopened.

(f) **Dust-loading Exposure Test.** A damper assembly shall close and latch automatically (if a latch is provided) following exposure for seven hours to an air-blown circulating grain dust-air mixture. The grain dust shall pass through a 100-mesh screen. A sample of the largest size (up to 46 inches wide by 42 inches high for vertical dampers and up to 28 inches wide by 46 inches long for horizontal dampers) and the smallest size damper are to be tested.

The test chamber is to be provided with observation windows and with auxiliary equipment to produce a circulating grain dust-air mixture. Nozzles are to be provided to direct the dust-air mixture toward the sample, and the dust particles are to be allowed to accumulate on the various parts of the damper assembly.

At the conclusion of the dust-loading exposure, the test sample is to be removed from the chamber, placed in its intended mounting position and tested for closing and latching (if a latch is provided).

(g) **Salt-spray Exposure Test.** A damper assembly shall close and latch automatically (if a latch is provided) following exposure for a period of five days to salt spray when tested as described in this section. Both the largest size (up to 46 inches wide by 42 inches high for vertical dampers and up to 28 inches wide by 46 inches long for horizontal dampers) and smallest size dampers are to be tested.

Prior to test, all dust grease or oil is to be removed from the test sample using organic solvents.

The test sample is to be installed in the test chamber with the damper open and supported in the position of intended use and exposed to the salt spray for 120 hours in accordance with approved methods, except that the salt solution is to consist of 20 percent by weight of common salt (sodium chloride) and distilled water. The pH value of this solution as collected after spraying in the test apparatus is to be between 6.5 and 7.2 and the specific gravity between 1.126 and 1.157 at 95°F. The temperature of the sample and the test chamber is to be maintained at 95 plus 2, minus 3°F. throughout the test period.

At the conclusion of the salt-spray exposure, the test sample is to be removed from the chamber and allowed to dry for 24 hours at room temperature. It then is to be placed in its intended mounting position and tested for closing and latching (if a latch is provided).

In cases where excessive buildup of zinc chloride has occurred due to reaction of the salt with galvanized steel coatings, such parts may be painted and a second sample subjected to test.

Classification

Sec. 43.1205. (a) **General.** The highest leakage obtained on the three representative samples tested in accordance with Section 43.1204 (d) shall be considered as the leakage classification for the overall design, as specified in Table No. 43-12-A.

Leakage at the prescribed pressure differentials shall be no greater than the values shown in Table No. 43-12-A within each classification.

Published ratings of performance shall be an accurate statement of the actual leakage flow of air (corrected to standard temperature and pressure conditions) at the specified pressure differential. The maximum degradation test temperature shall also be specified in the classification.

Classifications at pressure differentials of 8 or 12 inches of water shall be identified as "extended static range" classifications.

TABLE NO. 43-12-A
LEAKAGE CLASSIFICATIONS

	LEAKAGE, foot^3/minimum/foot^2	
Classification	**At 1.0 Inch Water**	**At 4.0 Inches Water**
0	0	0
I	4	8
II	10	20
III	40	80
IV	60	120
Extended Static Range	**At 8 Inches Water**	**At 12 Inches Water**
0	0	0
I	11	14
II	28	35
III	112	140
IV	168	210

Marking

Sec. 43.1206. Each damper (or each damper unit in a multiple assembly) shall be marked at a location that will be visible after installation with the following:

1. The manufacturer's or private labeler's name.

2. Model number or identifying symbol.
3. Date of manufacture which may be in code.
4. Arrow showing direction of airflow.
5. Installation mode—vertical and/or horizontal.
6. Leakage classification in accordance with Table No. 43-12-A.
7. Statement as to degradation test temperature—"Degradation Test Temperature __*__."
8. Maximum rated airflow rate and static pressure differential across the closed damper (4, 8 or 12 inches of water).
9. Required opening and closing torque (to be consistent with the torque required in Sections 43.1204 (d) and (e) and the intended operator/actuator).

Damper operators/actuators shall be marked with their electrical ratings if electrical, or the maximum pressure rating if pneumatic or hydraulic.

If a manufacturer produces dampers at more than one factory, each damper shall have a distinctive marking to identify it as the product of a particular factory.

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*Temperature indicated shall be ambient or the tested exposure temperature as specified in Section 43.1204 (c).

UNIFORM FIRE CODE STANDARD NO. 9-2
FLASH POINT BY PENSKY-MARTENS CLOSED TESTER

Based on Standard Test Method D93-75 of the American Society for Testing and Materials

See Section 404, Uniform Mechanical Code, and Section 9.108, Uniform Fire Code

Scope

Sec. 9.201. This standard is the test procedure for determining the flash point by the Pensky-Martens closed-cup tester of liquids with a viscosity of 5.82 centistokes or more at 100°F., a flash point of 200°F. or higher, suspensions of solids and liquids that tend to form a surface film under test conditions.

Apparatus

Sec. 9.202. Apparatus used for this test shall be an approved Pensky-Martens closed-cup flash tester. Support the tester on a level, steady table.

Sample

Sec. 9.203. Samples should not be stored in plastic (polyethylene, polypropylene, etc.) bottles, since volatile material may diffuse through the walls of the bottle.

Samples of very viscous materials may be warmed until they are reasonably fluid before they are tested. However, no sample should be heated more than is absolutely necessary. It shall never be heated above a temperature of 30°F. below its expected flash point.

Samples containing dissolved or free water may be dehydrated with calcium chloride or by filtering through a qualitative filter paper or a loose plug of dry absorbent cotton. Warming the sample is permitted, but it shall not be heated for prolonged periods or above a temperature of 30°F. below its expected flash point.

Procedure

Sec. 9.204. (a) **Basic Procedure.** Fill the cup with the sample to be tested to the level indicated by the filling mark. Place the lid on the cup and set the test cup in the stove. Insert the thermometer. Light the test flame and adjust it to 5/32 inch in diameter. Supply the heat at such a rate that the temperature as indicated by the thermometer increases 9°F. to 11°F. per minute. Turn the stirrer 90 to 120 rpm, stirring in a downward direction.

If the sample is know to have a flash point of 230°F. or below, apply the test flame when the temperature of the sample is from 30°F. to 50°F. below the expected flash point and thereafter at a temperature reading that is multiple of 2 °F. Apply the test flame by operating the mechanism on the cover which controls the shutter and test flame burner so that the flame is lowered into the vapor space of the cup in 0.5 second, left in its lowered position for 1 second and quickly raised to its high position. Do not stir the sample while applying the test flame.

If the sample is known to have a flash point above 230°F., apply the test flame in the manner just described at each temperature that is a multiple of 5°F., beginning at a temperature of 30°F. to 50°F. below the expected flash point.

When the test flame application causes a distinct flash in the interior of the cup, observe and record the temperature of the sample as the flash point. Occasionally, particularly near the actual flash point, the application of the test flame will cause a halo or an enlarged flame; this is not a flash and should be ignored.

Observe and record the ambient barometric pressure at the time of the test.

(b) **Procedure for Suspensions of Solids and Highly Viscous Materials.** Bring the material to be tested and the tester to a temperature of 60°F. ± 10°F. or 20°F. lower than the estimated flash point, whichever is lower. Turn the stirrer 250 rpm ± 10 rpm, stirring in a downward direction. Raise the temperature throughout the duration of the test at a rate of not less than 2°F. nor more than 3°F. per minute. With the exception of these requirements for rates of stirring and heating, proceed as prescribed in Subsection (a).

Flash Point

Sec. 9.205. The flash point shall be the temperature read on the thermometer to the nearest 1°F. at the time the test flame application causes a distinct flash in the interior of the cup. The recorded flash point shall be corrected when the pressure differs from 760 mm Hg as follows:

Corrected flash point $= F + 0.06\,(760 - P)$

WHERE:

F = observed flash point, °F.

P = ambient barometric pressure, mm Hg.

APPENDIX B

Chapter 21

Steam and Hot-water Boilers
Steam and Hot-water Piping
(Hydronics)

Purpose

Sec. 2101. The purpose of this chapter is to establish and provide minimum standards for the protection of public welfare, health, safety and property by regulating and controlling the quality, location and installation of steam and hot-water boilers.

Scope

Sec. 2102. The requirements of this chapter shall apply to the construction, installation, operation, repair and alteration of all boilers and pressure vessels.

EXCEPTIONS: 1. Listed and approved potable water heaters with a nominal capacity of 120 gallons or less having a heat input of 200,000 Btu/h or less used for hot-water supply at pressure of 160 pounds per square inch or less and at temperatures not exceeding 210°F. as regulated by the Plumbing Code.

2. Pressure vessels used for unheated water supply, including those containing air which serves only as a cushion and is compressed by the introduction of water and tanks connected to sprinkler systems.

3. Portable unfired pressure vessels and I.C.C. containers.

4. Containers for liquefied petroleum gases, bulk oxygen and medical gas, which are regulated by the Fire Code.

5. Unfired pressure vessels in Groups B, H, R and M Occupancies having a volume of 5 cubic feet or less and operated at pressures not exceeding 250 psi.

6. Pressure vessels used in refrigeration systems which are regulated by Chapter 15 of this code.

7. Pressure tanks used in conjunction with coaxial cables, telephone cables, power cables, and other similar humidity control systems.

8. Any boiler or pressure vessel subject to regular inspection by federal inspectors or licensed by federal authorities.

Workmanship

Sec. 2103. All equipment, appurtenances, devices and piping shall be installed in a workmanlike manner in conformity with the provisions and intent of this chapter.

Definitions

Sec. 2104. Certain words and terms used in this chapter, unless clearly inconsistent with their context, shall mean as follows:

AUTOMATIC BOILER. When applied to any class of boiler defined below, such boiler shall be equipped with certain controls and limit devices as specified in Section 2111 and Table No. 21-C.

BOILER is a closed vessel used for heating water or liquid, or for generating steam or vapor by direct application of heat from combustible fuels or electricity.

BURNER, AUTOMATIC BOILER. A burner for an automatic boiler is a device to convey fuel into the combustion chamber in proximity to its combustion air supply so as to permit a stable controlled heat release compatible with the burner design and which is equipped with an ignition system to reliably ignite the entire heat release surface of the burner assembly.

CONTINUOUS PILOT is a pilot that burns without turndown throughout the entire period that the boiler is in service, whether or not the main burner is firing.

HOT-WATER-HEATING BOILER is a boiler having volume exceeding 120 gallons, or a heat input exceeding 200,000 Btu/h, or an operating temperature exceeding 210°F. that provides hot water to be used externally to itself.

INTERLOCK is a device which senses a limit or off-limit condition or improper sequence of events and shuts down the offending or related piece of equipment or prevents proceeding in an improper sequence in order to prevent a hazardous condition developing.

INTERMITTENT PILOT is a pilot which burns during light-off and while the main burner is firing, and which is shut off with the main burner.

INTERRUPTED PILOT is a pilot which burns during light-off and which is shut off during normal operation of the main burner.

LOW-PRESSURE HOT-WATER-HEATING BOILER is a boiler in which water is heated for the purpose of supplying heat at pressures not exceeding 160 psi and temperatures not exceeding 250°F.

MINIATURE BOILER is a power boiler having an internal shell diameter of 16 inches or less, a gross volume of 5 cubic feet or less, a heating surface of 20 square feet or less (not applicable to electric boilers) and not exceeding 100 psi.

PACKAGE BOILER. May be any class of boiler defined herein and shall be a boiler equipped and shipped complete with fuel-burning equipment, automatic controls and accessories, and mechanical draft equipment, if used.

PILOT is a burner smaller than the main burner, which is ignited by a spark or other independent and stable ignition source, and which provides ignition energy required to immediately light off the main burner.

POWER BOILER is a boiler in which steam is generated at pressures exceeding 15 psi.

POWER HOT-WATER BOILER (HIGH-TEMPERATURE WATER BOILER) is a boiler used for heating water or liquid to a pressure exceeding 160 psi or to a temperature exceeding 250°F.

PRESSURE VESSEL (Unfired) is a closed container, having a nominal internal diameter exceeding 6 inches and a volume exceeding 1 1/2 cubic feet, for liquids, gases or vapors subjected to pressures exceeding 15 psi or steam under any pressure.

PURGE. Acceptable method of scavenging the combustion chamber, boiler passes and breeching to remove all combustible gases.

STEAM HEATING BOILER is a boiler operated at pressures not exceeding 15 psi for steam.

Permit Required

Sec. 2105. Except for work exempted by Subsection 301 (b) of this code, a permit shall be obtained from the building official prior to installation, alteration, repair or replacement of boilers and pressure vessels. Alteration of control systems on automatic boilers and the conversion of solid-fuel-fired boilers as permitted by Section 2113 shall also require a permit. See Chapter 3 for requirements for obtaining permits.

Detailed Requirements

Sec. 2106. (a) **Safety Requirements.** The construction of boilers and pressure vessels and the installation thereof shall conform to minimum requirements for safety from structural and mechanical failure and excessive pressures, established by the building official in accordance with nationally recognized standards.

(b) **Controls.** Required electrical, mechanical, safety and operating controls shall carry approval of an approved testing agency. Electrical controls shall be of such design and construction as to be suitable for installation in the environment in which they are located.

(c) **Gages.** All steam boilers shall be provided with a pressure gage and a water level glass. All water boilers shall be provided with a pressure gage and a temperature indicator.

(d) **Stack Dampers.** Stack dampers on boilers fired with oil or solid fuel shall not close off more than 80 percent of the stack area when closed, except on automatic boilers with prepurge, automatic draft control and interlock. Operative dampers shall not be placed within any stack, flue or vent of a gas-fired boiler, except on an automatic boiler with prepurge, automatic draft control and interlock.

(e) **Welding.** Welding on pressure vessels shall be done by approved welders in conformity with nationally recognized standards. All such welding shall be subject to the approval of the building official.

Expansion Tanks

Sec. 2107. (a) **General.** All hot-water-heating systems shall be provided with an air expansion tank securely fastened to the structure. Supports shall be adequate to carry twice the weight of the tank filled with water without placing any strain on connecting piping.

All hot-water heating systems incorporating hot-water tanks or fluid relief columns shall be so installed as to prevent freezing under normal operating conditions.

(b) **Systems with Open Expansion Tank.** Systems, equipped with an open expansion tank to satisfy thermal water expansion, shall be provided with an indoor overflow from the upper portion of the expansion tank in addition to an open vent. The indoor overflow shall be carried within the building to a suitable plumbing fixture or to the basement.

(c) **Closed-type Systems.** Systems of the closed type shall have an airtight tank or other suitable air cushion that will be consistent with the volume and capacity of the system, and shall be suitably designed for a hydrostatic test pressure of two and one half times the allowable working pressure of the system. Expansion tanks for systems designed to operate at or above 30 psig shall be constructed in accordance with nationally recognized standards approved by the building official. Provisions shall be made for draining the tank without emptying the system, except for pressurized tanks.

(d) **Minimum Capacity of Closed-type Tank.** The minimum capacity of the closed type expansion tank may be determined from Tables No. 21-A, No. 21-B or from the following formula:

$$V_t = \frac{(0.00041t - 0.0466)\, V_s}{\dfrac{P_a}{P_f} - \dfrac{P_a}{P_o}}$$

WHERE:

V_t = minimum volume of expansion tank, gallons.

V_s = volume of system, not including expansion tank, gallons.

t = average operating temperature, °F.

P_a = atmospheric pressure, feet H_2O absolute.

P_f = fill pressure, feet H_2O absolute.

P_o = maximum operating pressure, feet H_2O absolute.

Safety or Relief Valve Discharge

Sec. 2108. The discharge from relief valves shall be piped to within 18 inches of the floor or to an open receptacle, and when the operating temperature is in excess of 212°F., shall be equipped with a splash shield or centrifugal separator. When the discharge from safety valves would result in a hazardous discharge of steam inside the boiler room, such discharge shall be extended outside the boiler room. No valve of any description shall be placed between the safety or relief valve and the boiler, nor on the discharge pipe between the safety valve and the atmosphere.

Shutoff Valves

Sec. 2109. An approved manual shutoff valve shall be installed upstream of all control devices on the main burner of a gas-fired boiler. The takeoff point for the gas supply to the pilot shall be upstream of the gas shutoff valve of the main burner and shall be valved separately. A union or other approved means of disconnect shall be provided immediately downstream of these shutoff valves.

Gas-pressure Regulators

Sec. 2110. An approved gas-pressure regulator shall be installed on gas-fired boilers where the gas supply pressure is higher than that at which the main burner is designed to operate. A separate approved gas-pressure regulator shall be installed to regulate the gas pressure to the pilot or pilots. A separate regulator shall not be required for the pilot or pilots on manufacturer-assembled boiler-burner units which have been approved by the building official and on gas-fired boilers in Group R Occupancies of less than six units and in Group M Occupancies.

Low-water Cutoff

Sec. 2111. Hot-water-heating boilers, other than manually fired, shall be equipped with a low-water cutoff except that a coil-type boiler or a water-tube boiler which requires forced circulation to prevent overheating of the coils or tubes shall have a flow-sensing device installed in the outlet piping in lieu of the low-water cutoff. The required low-water cutoff or flow switch, as applicable, shall be mounted so as to prevent damage to the boiler and to permit testing of the fuel-supply cutoff without draining the heating system, except that such boilers used in Group R Occupancies of less than six dwelling units and Group M Occupancies need not be equipped with the low-water cutoff or flow switch.

Combustion Regulators: Safety Valves

Sec. 2112. The following requirements shall be retroactive:

1. Every hot-water-heating boiler, other than manually fired, shall be equipped with two temperature combustion regulators in series. Every steam heating boiler, other than manually fired, shall be equipped with a pressure combustion regulator and a low-water cutoff. (See Section 2111.)

2. Boilers and pressure vessels shall be provided with the required number, size and capacity of safety or relief valves to ensure positive relief of overpressure in accordance with nationally recognized standards, as applicable. Valves so employed shall be constructed, sealed and installed in accordance with nationally recognized standards, as applicable.

Automatic Boilers

Sec. 2113. Automatic boilers shall be equipped with controls and limit devices as set forth in Table No. 21-C. Automatic boilers shall also be equipped with the following gages, as applicable: oil temperature, oil suction pressure, high and low gas pressure, stack temperature and windbox pressure.

Except as otherwise specified, gas-fired boilers exceeding 400,000 Btu/h input shall conform to nationally recognized standards approved by the building official.

The building official may approve solid-fuel-fired boilers that can meet the safety requirements for automatic gas- or oil-fired boilers.

Clearance for Access

Sec. 2114. When boilers are installed or replaced, clearance shall be provided to allow access for inspection, maintenance and repair. Passageways around all sides of boilers shall have an unobstructed width of not less than 18 inches. Clearance for repair and cleaning may be provided through a door or access panel into another area, provided the opening is of sufficient size.

> **EXCEPTION:** Subject to the approval of the building official, boilers may be installed with a side clearance of less than 18 inches, provided that the lesser clearance does not inhibit inspection, maintenance or repair.

Power boilers having a steam generating capacity in excess of 5000 pounds per hour or having a heating surface in excess of 1000 square feet or input in excess of 5,000,000 Btu/h shall have a minimum clearance of 7 feet from the top of the boiler to the ceiling.

Steam heating boilers and hot-water-heating boilers which exceed one of the following limits: 5,000,000 Btu/h input; 5000-pound-steam-per-hour capacity or 1000-square-foot heating surface; and power boilers which do not exceed one of the following limits: 5,000,000 Btu/h input; 5000-pound-steam-per-hour capacity or 1000-square-foot heating surface; and all boilers with manholes on top of the boiler, except those described in the second and fourth paragraphs shall have a minimum clearance of 3 feet from the top of the boiler to the ceiling.

Package boilers, steam heating boilers and hot-water-heating boilers with no manhole on top of shell and not exceeding one of the above limits shall have a minimum clearance of 2 feet from the ceiling.

Boiler Rooms and Enclosures

Sec. 2115. Boiler rooms and enclosures and access thereto shall comply with Chapter 7 of this code and the Building Code.

Mounting

Sec. 2116. Equipment shall be set or mounted on a level base capable of supporting and distributing the weight contained thereon.

Boilers, tanks and equipment shall be securely anchored to the structure.

Equipment requiring vibration isolation shall be installed as designed by a registered engineer to the satisfaction of the building official.

Floors

Sec. 2117. Boilers shall be mounted on floors of noncombustible construction unless listed for mounting on combustible flooring.

Chimneys or Vents

Sec. 2118. Boilers shall be connected to a chimney or vent as provided for other fuel-burning equipment as provided for in Chapter 9 of this code.

Drainage

Sec. 2119. For heating or hot-water-supply boiler applications, the boiler room shall be equipped with a floor drain or other means suitable for disposing of the accumulation of liquid wastes incident to cleaning, recharging and routine maintenance.

Fuel Piping

Sec. 2120. Fuel piping shall conform to Chapter 22 or the standard cited in Appendix C, Reference Standards—Oil Tanks, Piping, etc.

Air for Combustion and Ventilation

Sec. 2121. Air for combustion and ventilation shall be provided in accordance with Chapter 6 of this code.

Operating Adjustments and Instructions

Sec. 2122. Hot-water boiler installations upon completion shall have controls set, adjusted and tested by the installing contractor. A complete control diagram of a permanent legible type, together with complete boiler operating instructions, shall be furnished by the installer for each installation.

Inspections and Tests

Sec. 2123. An installation for which a permit is required shall not be put into service until it has been inspected and approved by the building official.

It shall be the duty of the owner or his authorized representative to notify the building official that the installation is ready for inspection and test. It also shall be the duty of the owner or his authorized representative to post in a conspicuous position on the installation a notice in substantially the following form: "Warning! This installation has not been inspected and approved by the building official and shall not be covered or concealed until so inspected and approved," and it shall be unlawful for anyone other than the building official to remove such notice. The building official shall require such tests as he deems necessary to determine that the installation complies with the provision of this code. Such tests shall be made by the owner or his authorized representative in the presence of the building official.

> **EXCEPTION:** On installations designed and supervised by a registered professional engineer, the building official may permit inspection and testing by such engineer in lieu of the above requirements.

When the owner or his authorized representative requests inspection of a boiler prior to its installation, the building official shall make such inspection.

Operating Permit

Sec. 2124. It shall be unlawful to operate a boiler or pressure vessel without first obtaining a valid operating permit to do so from the building official. Such permit shall be displayed in a conspicuous place adjacent to boiler or vessel. The operating permit shall not be issued until the equipment has been inspected and approved by the building official.

> **EXCEPTION:** The operation only of steam heating boilers, low-pressure hot-water-heating boilers, hot-water-supply boilers and pressure vessels in Group R Occupancies of less than six dwelling units and in Group M Occupancies.

Maintenance Inspection

Sec. 2125. The building official shall inspect all boilers and pressure vessels operated under permit at such intervals as he deems necessary but not less frequently than noted below:

1. Power boilers and miniature boilers shall be inspected externally annually. Where construction and operating conditions permit, they shall, in addition, be subject to inspection internally annually.

2. Steam heating boilers and hot-water-heating boilers shall be inspected externally annually. Where construction and operating conditions permit, they shall, in addition, be subject to inspection internally annually.

3. Automatic steam heating boilers shall be inspected externally biennially. Where construction and operating conditions permit, they shall, in addition, be subject to inspection internally biennially.

4. Unfired pressure vessels shall be inspected externally biennially. When subject to corrosion and construction permits, they shall, in addition, be subject to inspection internally biennially.

Inspection of boilers and pressure vessels covered by insurance may be made by employees of the insuring company holding commissions from the National Board of Boiler and Pressure Vessel Inspectors, subject to approval of the building official. Approved insuring company inspectors shall make reports on prescribed forms on inspections authorized by the building official, the reports shall be filed in the building official's office. Company inspectors shall notify the building official of suspension of insurance because of dangerous conditions, new insurance in effect, and discontinuance of insurance coverage.

Operation and Maintenance of Boilers and Pressure Vessels

Sec. 2126. Boilers and pressure vessels shall be operated and maintained in conformity with requirements for adequate protection of the public established by the building official in accordance with nationally recognized standards.

The building official shall notify the owner or authorized representative of defects or deficiencies which shall be promptly and properly corrected. If such corrections are not made, or if the operation of the boiler or pressure vessel is deemed unsafe by the building official, the permit to operate the boiler or pressure vessel may be revoked. If the operation of a boiler or pressure vessel is deemed by the building official to constitute an immediate danger, the pressure on such boiler or pressure vessel may be relieved at the owner's cost and the boiler or pressure vessel shall not thereafter be operated without approval of the building official.

Steam and Water Piping

Sec. 2127. Steam and water piping systems which are part of a heating or cooling system, shall comply with the following requirements:

1. Those portions of piping systems in which the pressure exceeds 160 psig or the temperature exceeds 250°F., shall comply with nationally recognized standards approved by the building official and the requirements of Item No. 2.

2. Those portions of piping systems in which the pressure does not exceed 160 psig and the temperature does not exceed 250°F., shall comply with the following requirements:

A. **Materials and construction.** (1) **Pipe.** Pipe shall be brass, copper, cast iron, galvanized or black wrought iron, galvanized or black steel, or other approved materials.

(2) **Tubing.** Tubing shall be copper water tube.

(3) **Valves.** Valves up through 2 inches in size shall be brass, malleable iron, or

steel bodies. Each gate valve shall be a full-way type with working parts of noncorrosive metal.

(4) **Fittings.** (i) Plain screwed fitting shall be brass, bronze, cast iron or galvanized or black malleable iron, or galvanized or black steel.

(ii) Fittings for copper tubing shall be wrought copper, wrought bronze or cast brass.

(iii) Welding fittings shall be black steel.

(iv) Fittings for asbestos-cement shall be cast iron.

(5) **Pipe joint compound.** Pipe joint compound shall be noncorrosive and insoluble in the material being carried in the pipe.

(6) **Protective coatings.** Protective coatings shall be watertight, durable, heat resistant, electrically nonconductive and tightly adherent to the pipe.

(7) **Fluxes.** Fluxes for solder, sweat, and brazed joints shall be a noncorrosive type and suitable for the use intended.

(8) **Insulation.** Coverings or insulation used on hot-water or steam pipes shall be of materials suitable for the operating temperature of the system. The insulation, jackets and lap-seal adhesives shall be tested as a composite product and shall have a flame spread of not more than 25 and a smoke-developed rating of not more than 50 when tested in accordance with U.B.C. Standard No. 42-1.

(9) **Flashing material.** Flashings shall be lead, copper, galvanized iron or other approved materials.

(10) **Gaskets.** Flange gaskets shall be metal or asbestos or other approved materials.

(11) **Hangers and anchors.** Hangers and anchors shall be suitable for the use intended.

(12) **Sleeves.** Sleeves shall be of steel, cast iron or wrought iron pipe, or tile.

(13) **Standards.** All piping, tubing, valves, joints, fittings, devices and materials shall be free of defects and comply with nationally recognized standards approved by the building official.

(14) **Marking.** Materials and devices shall be suitably identified. In addition to the incised marking required in the standards, all hard-drawn copper tubing shall be marked by means of a continuous and indelible colored stripe, at least 1/4 inch in width as follows:

Type L—Blue
Type K—Green
Type M—Red

(15) **Other materials.** Other materials and construction may be installed as provided in this chapter or in their approval, provided that they are first acceptable to the building official and are equivalent, for the use intended, to those specified in this chapter.

B. **Fabrication of joints.** Joints shall be made by use of fittings except as otherwise permitted in this chapter.

(1) **Screwed joints.** Threads on iron pipe size (I.P.S. pipe) shall be standard taper pipe threads. All burrs shall be removed. Pipe ends shall be reamed or filed out to full size of bore and all chips shall be removed.

(2) **Solder joints.** Surfaces to be joined by soldering shall be cleaned bright by manual or mechanical means. The joints shall be properly fluxed. Tubing shall be reamed out to the full size of bore.

(3) **Welded joints.** Welding shall be performed in accordance with nationally recognized standards approved by the building official.

(4) **Flanged joints.** Flanged joints shall be tightened evenly and provided with suitable nuts, bolts and gaskets.

(5) **Mechanical joints.** Mechanical joints shall comply with nationally recognized standards.

C. **Connections.** (1) **Brass and copper piping.** Joints in brass and copper piping shall be threaded, brazed, welded, flanged or mechanical type.

(2) **Cast-iron piping.** Joints in cast-iron pipe shall be threaded, flanged or mechanical type.

(3) **Galvanized wrought-iron and galvanized steel piping.** Joints in galvanized wrought-iron and galvanized steel piping shall be threaded, flanged or mechanical type.

(4) **Black wrought-iron piping.** Joints in black wrought-iron piping shall be threaded, brazed, welded, flanged or mechanical type except that joints built into or embedded in concrete or masonry shall be welded.

(5) **Black steel piping.** Joints in black steel piping shall be threaded, brazed, welded, flanged or mechanical type.

(6) **Asbestos-cement piping.** Joints in asbestos-cement piping shall be mechanical type and suitable for the service temperature intended.

(7) **Copper water tubing.** Joints in copper tubing shall be soldered, sweated, or brazed; except that joints under a building and in or under any concrete slab resting on the ground, shall be silver brazed, or equal, and fittings shall be of wrought copper. All solder and sweat joints may be made with 95 percent tin—5 percent antimony solder; however, if the steam pressure does not exceed 15 psig nor the water pressure exceed 30 psig, then 50 percent tin—50 percent lead solder may be used. Lead-based solders shall not be used in piping conveying potable water.

(8) **Piping to tubing.** Joints connecting piping to tubing shall be made with adapter fittings connected as required in Item Nos. (1) through (7).

D. **Changes in direction.** Changes in direction shall be made by the appropriate use of fittings, except that changes in direction in copper tubing may be made with bends having a radius not less than six diameters of the tubing, provided that such bends are made by the use of forming equipment which does not deform or reduce appreciably the cross-sectional area of the tubing.

E. **Changes in pipe sizes.** Where different sizes of pipe or pipe and fittings are to be connected, the proper size increasers or reducer fittings shall be used between the two sizes. When the branch is at least two sizes smaller than the main, weldolets or threadolets may be used in lieu of welding tees. Bushings shall not be used. Eccentric reducing fittings shall be used wherever necessary to provide free drainage of lines.

F. **Hangers and supports.** All piping and equipment shall be adequately supported to the satisfaction of the building official. Hot-water and steam piping shall be supported, anchored, provided with swing joints, expansion loops or joints, or other means to avoid excessive strain on piping, equipment, or the building structure to the satisfaction of the building official.

(1) **Vertical piping—attachment.** Vertical piping and tubing shall be secured at sufficiently close intervals to keep the pipe in alignment and carry the weight of the pipe and contents.

(2) **Horizontal piping.** (i) **Supports.** Horizontal piping and tubing shall be supported at sufficiently close intervals to keep it in alignment and prevent excessive sagging.

(ii) **In ground.** Piping and tubing in the ground shall be laid on a firm bed for its entire length, except where support is otherwise provided which is adequate in the judgment of the building official. Asbestos-cement piping shall be provided with adequate blocking.

G. **Installation.** (1) **Same materials required.** All piping materials used, except valves and similar devices, shall be of a like material except as otherwise acceptable to the building official.

(2) **Wall thickness.** (i) Piping shall be at least standard weight brass or copper, Class 150 cast iron, standard weight wrought iron, ASTM Schedule 40 steel, or suitable asbestos-cement of adequate pressure rating.

(ii) **Tubing shall be at least:** Type K—for condensate return lines; Type L—for steam condenser cooling water lines, underground water lines, and aboveground water lines; Type M—for aboveground water lines not embedded in concrete or masonry.

(3) **Piping embedded in structure.** Piping shall not be built into or embedded in concrete or masonry; except, where used for radiant panel heating or cooling, black steel pipe, wrought-iron piping or Type L copper tubing may be so embedded.

(4) **Cutting structure.** Structural member shall not be seriously weakened or impaired by cutting or notching.

(5) **Providing for expansion, contraction and settling.** Piping shall be installed so that piping, connections and equipment shall not be subjected to excessive strains or stresses and provisions shall be made for expansion, contraction, shrinkage, and structural settlement.

(6) **Circulation.** Piping shall provide adequate circulation. Piping shall be graded so that all gases can move in the direction of the water flow to a vented section of the system. When sections of a piping system cannot be installed with the required grade, such sections shall be provided with automatic or manual air vents whose discharge is piped to an approved location. Steam traps shall be provided where required.

(7) **Underground piping.** (i) **Cinders and other corrosive material fills.** All

piping passing through or under cinders or other corrosive fill materials shall be suitably protected from corrosion.

> **EXCEPTION:** Where a soil analysis by an acceptable testing laboratory shows the soil to be free of materials which may corrode the pipe to be installed, the requirements for protective coatings may be waived.

(ii) **Beneath buildings.** Piping installed within a building and in, or under, a concrete floor slab resting on the ground shall be installed as follows:

Ferrous piping. Ferrous piping shall be galvanized and covered with an approved protective coating.

Copper tubing. Copper tubing shall be installed without joints where possible.

Asbestos-cement. Asbestos-cement pipe shall not be installed beneath any building.

(iii) **Outside of buildings—black wrought iron and black steel.** Black wrought-iron and black steel piping shall be protected against corrosion by an approved pipe wrapping.

Asbestos-cement. Asbestos-cement piping shall be installed in accordance with the manufacturer's recommendations, but shall not be installed within 2 feet of any building.

(iv) **Under walls or foundations.** Piping passing under walls or foundations shall be protected from breakage.

(v) **Openings into buildings.** Voids around piping passing through concrete or masonry floors or walls shall be appropriately sealed at the opening into the building; sleeves shall be provided at such openings.

(8) **Aboveground piping.** (i) **Sleeves.** Sleeves shall be installed where piping passes through masonry or concrete, or through any fire separation.

(ii) **Insulation.** The temperature of surfaces within normal reach of building occupants shall not exceed 140°F. unless they are protected by suitable insulation. Where sleeves are installed any insulation shall continue full-sized through them.

(iii) **Lining.** Combustible portions of unventilated spaces which contain piping or devices whose outside temperature, including insulation, exceeds 140°F., shall be lined with No. 24 gage steel, or 1/4-inch-thick insulating millboard.

(iv) **Clearance.** There shall be at least 1-inch clearance from structure around steam pipes.

(v) **Exposed piping.** Exposed piping subject to excessive corrosion, erosion, or mechanical damage shall be suitably protected.

(vi) **Asbestos-cement piping.** Asbestos-cement piping shall not be installed within any building.

(vii) **Roof and wall openings.** Joints at the roof around pipes or appurtenances shall be made watertight by the use of approved flashings or flashing material. Exterior wall openings shall be made watertight.

(viii) **Drainage.** Means shall be provided to drain all piping.

(ix) **Freezing.** Where required, piping outside of a building or in an exterior wall shall be protected from freezing.

(9) **Trenches and tunnels.** (i) **Protection of structure.** Trenches deeper than the footings of a building or structure and paralleling the same shall be at least 45 degrees therefrom, unless otherwise permitted by the building official.

(ii) **Mechanical equipment.** Use of mechanical excavating equipment is prohibited within 2 feet of existing piping or appurtenances.

(iii) **Tunneling and driving.** Tunnels shall, before backfilling, have a clear height of 2 feet above the pipe and shall be limited in length to one half the depth of the trench, with a maximum length of 8 feet. When pipes are driven, the drive pipe shall be at least one size larger than the pipe to be laid.

(iv) **Backfilling.** Excavations shall be completely backfilled as soon after inspection as practicable. Adequate precaution shall be taken to ensure proper compaction of backfill around piping without damage to such piping. Trenches shall be backfilled in thin layers to 12 inches above the top of the piping with clean earth which shall not contain stones, boulders, cinder-fill or other materials which would damage or break the piping or cause corrosive action. Mechanical devices such as bulldozers, graders, etc., may then be used to complete backfill to grade. Fill shall be properly compacted. Suitable precautions shall be taken to ensure permanent stability for pipe laid in filled or made ground.

H. **Pressure testing.** (1) **Responsibility.** The equipment, material and labor necessary for inspection or test shall be furnished by the person to whom the permit is issued or by whom inspection is requested.

(2) **Media.** The piping shall be tested with water.

(3) **Pressure test.** Piping shall be tested with a hydrostatic pressure of not less than 100 psig, but at least 50 psig greater than operating pressure. This pressure shall be maintained for at least 30 minutes. Required tests shall be conducted by the owner or contractor in the presence of an authorized inspector. The piping being tested shall remain exposed to the inspector and shall not leak during the test.

(4) **Moved structures.** Piping systems of a building and parts thereof, that are moved from one foundation to another shall be completely tested as prescribed elsewhere in this section for new work, except that walls or floors need not be removed during such test when equivalent means of inspection acceptable to the building official are provided.

(5) **Test waived.** No test or inspection shall be required where a system, or part thereof, is set up for exhibition purposes and has no connection with a water system.

(6) **Exceptions.** In cases where it would be impractical to provide the aforementioned tests, or for minor installations and repairs, the building official at his discretion may make such inspection as he deems advisable in order to assure himself that the work has been performed in accordance with the intent of this chapter.

3. Those portions of the hot-water piping systems in which the continuous

pressure-temperature relationship does not exceed the following may be constructed of polybutylene pipe or tubing of SDR-11 conforming to specification ASTM D 3309.

TEMPERATURE (°F.)	PRESSURE (PSI)
73	200
180	100
200	80

Polybutylene also may be used for applications requiring up to one year total exposure at conditions of 210°F., 150 psi, typical conditions for temperature and pressure-relief valve discharge lines in heating systems.

A. **Materials and construction.** (1) **PB pipe and tubing.** Pipe shall be IPS or copper tube size polybutylene, both SDR-11 conforming to ASTM D 3309.

(2) **Fittings.** Fittings shall be of polybutylene or metal.

(3) **Insulation.** Coverings and insulation used on hot-water pipes shall be of materials suitable for the operating temperature of the system. The insulation, jackets and lap-seal adhesives shall be tested as a composite product and shall have a flame spread of not more than 25 and a smoke-developed rating of not more than 50 when tested in accordance with U.B.C. Standard No. 42-1.

(4) **Gaskets.** Flanged PB systems may be installed without gaskets.

(5) **Hangers, sleeves and anchors.** Hangers, sleeves and anchors shall be suitable for the use intended as recommended by the manufacturer's installation instructions.

(6) **Standards.** All piping, tubing, valves, joints, fittings, devices and materials shall be free of defects and comply with nationally recognized standards approved by the building official.

(7) **Marking.** Materials and devices shall be suitably identified.

B. **Fabrication of joints.** Joints shall be made by one or more of the following methods:

(1) **Socket fusion.** Polybutylene socket fittings may be heat fused to the pipe.

(2) **Crimp/Insert fittings.** Insert fittings of metal with crimp rings of aluminum or copper may be used.

(3) **Compression fittings.** Metallic or polybutylene fittings utilizing compression seals are acceptable.

(4) **Transition fittings.** Connections to other piping materials shall be made by approved types of special transition fittings.

C. **Changes in direction.** Changes in direction shall be made by the appropriate use of fittings or with pipe bends having a radius of not less than 10 diameters of the pipe. No forming equipment or heating is required.

D. **Hangers and supports.** Piping and equipment shall be adequately supported to the satisfaction of the building official. Hot-water piping shall be supported, anchored and provided with swing joints, expansion loops or joints, or utilize the pipe's flexibility to avoid excessive strain on piping, equipment or the building structure to the satisfaction of the building official.

E. **Installation details.** (1) **Piping embedded in structure.** Piping shall not be built into or embedded in concrete or masonry, except where used for radiant panel heating or cooling. See Chapter 23 of this appendix.

(2) **Cutting structure.** Structural member shall not be seriously weakened or impaired by cutting or notching.

(3) **Under walls or foundations.** All piping passing under load-bearing foundations shall be protected by sleeving.

(4) **Openings into buildings.** Voids around piping passing through concrete or masonry floors or walls shall be appropriately sealed at the opening into the building; sleeves shall be provided at such openings.

(5) **Above ground piping.** (i) **Sleeves.** Sleeves shall be installed where piping passes through masonry or concrete, or through any fire separation.

(ii) **Insulation.** The temperature of surfaces within normal reach of building occupants shall not exceed 140°F. unless they are protected by suitable insulation. Where sleeves are installed, any insulation shall continue full sized through them.

(6) **Belowground piping.** (i) **Protection of structure.** All trenches deeper than the footings of any building or structure and paralleling the same shall be at least 45 degrees therefrom, unless otherwise permitted by the building official.

(ii) **Mechanical equipment.** Use of mechanical excavating equipment is prohibited within 2 feet of existing piping or appurtenances.

(iii) **Boring and pulling.** Boring pipe shall be at least one size larger than the pipe to be laid. Pulling force shall not exceed the tensile yield strength of the pipe.

(iv) **Backfilling.** All excavations shall be completely backfilled as soon after inspection as practicable. Adequate precaution shall be taken to ensure proper compaction of the backfill around piping without damage to such piping. Trenches shall be backfilled in thin layers to 12 inches above the top of the piping with clean earth which shall not contain stones, boulders, cinderfill or other materials which would damage or break the piping. Mechanical devices such as bulldozers, graders, etc., may then be used to complete backfill to grade. Fill shall be properly compacted. Suitable precautions shall be taken to ensure permanent stability for pipe laid in filled or made ground.

(v) **Pipe or tube under concrete.** Pipe or tubing installed beneath footings or slab shall be in continuous lengths or with fused joints.

F. **Pressure testing.** (1) **Responsibility.** The equipment, material and labor necessary for inspection or test shall be furnished by the person to whom the permit is issued or by whom inspection is requested.

(2) **Media.** The piping shall be tested with water.

(3) **Pressure test.** Piping shall be tested with a hydrostatic pressure of not less than 100 psig or 1.5 times the system design operating pressure. The pressure shall be maintained for 30 minutes at which time the indicated pressure may have decreased due to the initial expansion of the pipe. After 30 minutes, adjust the system to the required pressure and visually inspect for leaks. Required tests shall

be conducted by the owner or contractor in the presence of an authorized inspector. The piping being tested shall remain exposed to the inspector and shall not leak during the test.

TABLE NO. 21-A—EXPANSION TANK CAPACITIES FOR GRAVITY HOT-WATER SYSTEMS

Based on two-pipe system with average operating water temperature 170°F., using cast-iron column radiation with heat emission rate 150 Btu per hour per square foot equivalent direct radiation.

SQUARE FEET OF INSTALLED EQUIVALENT DIRECT RADIATION[1]	TANK CAPACITY, GALLONS
Up to 350	18
Up to 450	21
Up to 650	24
Up to 900	30
Up to 1100	35
Up to 1400	40
Up to 1600	2 – 30
Up to 1800	2 – 30
Up to 2000	2 – 35
Up to 2400	2 – 40

[1] For systems with more than 2400 square feet of installed equivalent direct water radiation, the required capacity of the cushion tank shall be increased on the basis of 1-gallon tank capacity per 33 square feet of additional equivalent direct radiation.

TABLE NO. 21-B—EXPANSION TANK CAPACITIES FOR FORCED HOT-WATER SYSTEMS

Based on average operating water temperature 195°F., a fill pressure 12 psig, and maximum operating pressure 30 psig

SYSTEM VOLUME[1] GALLONS	TANK CAPACITY GALLONS
100	15
200	30
300	45
400	60
500	75
1000	150
2000	300

[1] Includes volume water in boiler, radiation and piping, not including expansion tank.

TABLE NO. 21-C—CONTROLS AND LIMIT DEVICES FOR AUTOMATIC BOILERS

				SAFETY CONTROL TIMING (Nominal Maximum Time in Seconds)											
					TRIAL FOR MAIN BURNER FLAME										
BOILER GROUP	FUEL	FUEL INPUT RANGE[1] (Inclusive)	TYPE OF PILOT[2]	TRIAL FOR PILOT	DIRECT ELECTRIC IGNITION	FLAME PILOT	MAIN BURNER FLAME FAILURE[3]	ASSURED FUEL SUPPLY CONTROL[4]	ASSURED AIR SUPPLY CONTROL[5]	LOW FIRE START UP CONTROL[6]	PRE-PURGING CONTROL[7]	HOT WATER TEMPERATURE AND LOW WATER LIMIT CONTROLS[8]	STEAM PRESSURE AND LOW WATER LIMIT CONTROLS[9]	APPROVED FUEL SHUTOFF[10]	CONTROL AND LIMIT DEVICE SYSTEM DESIGN[11]
A	Gas	0-400,000 Btu/h	Any type	90	Not Required	90	90	Not Required	Required	Not Required	Not Required	Required	Required	Not Required	Required
B	Gas	400,001-2,500,000 Btu/h	Interrupted or intermittent	15	15	15	2-4	Not Required	Required	Not Required	Not Required	Required	Required	Not Required	Required
C	Gas	2,500,001-5,000,000 Btu/h	Interrupted or intermittent	15	15	15	2-4	Required	Required	Required	Required	Required	Required	Required	Required
D	Gas	Over 5,000,000 Btu/h	Interrupted	15	15	15	2-4	Required	Required	Required	Required	Required	Required	Required	Required
E	Oil	0-400,000 Btu/h	Any type	Not Required	90	90	90	Not Required	Required	Not Required	Not Required	Required	Required	Not Required	Required
F	Oil	400,001-1,000,000 Btu/h	Interrupted	Not Required	30	30	2-4	Required	Required	Not Required	Not Required	Required	Required	Not Required	Required
G	Oil	1,000,001-3,000,000 Btu/h	Interrupted	Not Required	15	15	2-4	Required	Required	Not Required	Not Required	Required	Required	Not Required	Required
H	Oil	Over 3,000,000 Btu/h	Interrupted	15	15	60	2-4	Required	Required	Required	Required	Required	Required	Required	Required
K	Electric	All	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required	Required	Required	Not Required	Required

(Continued)

FOOTNOTES FOR TABLE NO. 21-C

[1] Fuel input shall be determined by one of the following:
(a) The maximum burner input as shown on the burner nameplate or as otherwise identified by the manufacturer.
(b) The nominal boiler rating, as determined by the building official, plus 25 percent.

[2] Automatic boilers shall have one flame failure device on each burner which shall prove the presence of a suitable ignition source at the point where it will reliably ignite the main burner, except that boiler groups A, B, E, F and G which are equipped with direct electric ignition shall monitor the main burner, and all boiler groups using interrupted pilots shall monitor only the main burner after the prescribed limited trial and ignition periods. Boiler group A equipped with continuous pilot shall accomplish 100 percent shutoff within 90 seconds upon pilot flame failure. The use of intermittent pilots in boiler group C is limited to approved burner units.

[3] In boiler groups B, C and D a 90-second main burner flame failure limit may apply if continuous pilots are provided on manufacturer assembled boiler-burner units which have been approved by an approved testing agency as complying with nationally recognized standards approved by the building official. Boiler groups F and G equipped to re-energize their ignition system within 0.8 second after main burner flame failure will be permitted 30 seconds for group F or 15 seconds for group G to re-establish its main burner flame.

[4] Boiler groups C and D shall have controls interlocked to accomplish a nonrecycling fuel shutoff upon high or low gas pressure, and boiler groups F, G and H using steam or air for fuel atomization shall have controls interlocked to accomplish a nonrecycling fuel shutoff upon low atomizing steam or air pressure. Boiler groups F, G and H equipped with a preheated oil system shall have controls interlocked to provide fuel shutoff upon low oil temperature.

[5] Automatic boilers shall have controls interlocked to shut off the fuel supply in the event of draft failure if forced or induced draft fans are used or, in the event of low combustion air flow, if a gas power burner is used. Where a single motor directly driving both the fan and the oil pump is used, a separate control is not required.

[6] Boiler groups, C, D and H when firing in excess of 400,000 Btu per combustion chamber shall be provided with low fire start of its main burner system to permit smooth light-off. This will normally be a rate of approximately one third of its maximum firing rate.

[7] Boiler groups C, D and H shall not permit pilot or main burner trial for ignition operation before a purging operation of sufficient duration to permit a minimum of four complete air changes through the furnace, including combustion chamber and the boiler passes. Where this is not readily determinable, five complete air changes of the furnace, including combustion chamber up to the first pass, will be considered equivalent. An atmospheric gas burner with no mechanical means of creating air movement or an oil burner which obtains two thirds or more of the air required for combustion without mechanical means of creating air movement shall not require purge by means of four air changes so long as its secondary air openings are not provided with means of closing. If such burners have means of closing secondary air openings, a time delay must be provided which puts these closures in a normally open position for four minutes before an attempt for ignition. An installation with a trapped combustion chamber shall in every case be provided with a mechanical means of creating air movement for purging.

[8] Every automatic hot-water-heating boiler, low-pressure hot-water-heating boiler, and power hot-water boiler shall be equipped with two high-temperature limit controls with a manual reset on the control with the higher setting interlocked to shut off the main fuel supply, except that manual reset on the high-temperature limit control shall not be required on any automatic package boiler not exceeding 400,000 Btu/h input and which has been approved by an approved testing agency. Every automatic hot-water heating, power boiler and package hot-water supply boiler shall be equipped with one low-water level limit control with a manual reset interlocked to shut off the fuel supply so installed as to prevent damage to the boiler and to permit testing of the control without draining the heating system except on boilers used in Group R Occupancies of less than six units and in Group M Occupancies and further, except that the low-water level limit control is not required on package hot-water supply boilers approved by a nationally recognized testing agency. However, a low-water flow limit control installed in the circulating water line may be used instead of the low-water level limit control for the same purpose on coil-type boilers.

[9] Every automatic low-pressure steam-heating boiler, small power boiler and power steam boiler shall be equipped with two high-steam pressure limit controls interlocked to shut off the fuel supply to the main burner with manual reset on the control with the higher setting and two low-water-level limit controls, one of which shall be provided with a manual reset device and independent of the feed water controller. Coil-type flash steam boilers may use two high-temperature limit controls, one of which shall be manually reset in the hot-water coil section of the boiler instead of the low-water level limit control.

[10] Boiler Groups C, D and H shall use an approved automatic reset safety shutoff valve for the main burner fuel shutoff which shall be interlocked to the programming control devices required. On oil burners where the safety shutoff valve will be subjected to pressures in excess of 10 psi when the burner is not firing, a second safety shutoff valve shall be provided in series with the first. Boiler Groups C and D using gas in excess of 1-pound-per-square-inch pressure or having a trapped combustion chamber or employing horizontal fire tubes shall be equipped with two approved safety shutoff valves, one of which shall be an automatic reset type, one of which may be used as an operating control, and both of which shall be interlocked to the limit-control devices required. Boiler Groups C and D using gas in excess of 1-pound-per-square-inch pressure shall be provided with a permanent and ready means for making periodic tightness checks of the main fuel safety shutoff valves.

[11] Control and limit device system shall be grounded with operating voltage not to exceed 150 volts, except that, upon approval by the building official, existing control equipment to be reused in an altered boiler control system may use 220-volt single phase with one side grounded, provided such voltage is used for all controls. Control and limit devices shall interrupt the ungrounded side of the circuit. A readily accessible means of manually disconnecting the control circuit shall be provided with controls so arranged that when they are de-energized the burner shall be inoperative.

Chapter 22

FUEL-GAS PIPING

Based on Chapter 12 and Appendix E of the Uniform Plumbing Code

General

Sec. 2201. The regulations of this chapter shall govern the installation of fuel-gas piping in or in connection with a building or structure or within the property lines of premises, other than service pipe.

Definitions

Sec. 2202. For the purposes of this chapter, certain terms, phrases, words and their derivatives shall be interpreted as set forth in this section, provided, however, that whenever the words "gas meters" appear, they shall be construed to also mean valves and devices required for the regulation of pressure and the measurement of natural gas being dispensed for a building, structure or premises.

APPLIANCE FUEL CONNECTOR is an assembly of listed semirigid or flexible tubing and fittings to carry fuel between a fuel piping outlet and a fuel-burning appliance.

APPROVED. See Section 403.

FUEL GAS is natural, manufactured, liquefied petroleum or a mixture of these.

GAS PIPING is an installation of pipe, valves or fittings that is used to convey fuel gas, installed on a premises or in a building, but shall not include:

1. Portions of the service piping.
2. Approved appliance fuel connectors 6 feet or less in length between an existing gas outlet and a gas appliance in the same room with the outlet.

GAS PIPING SYSTEM is an arrangement of gas piping supplied by a single meter or each arrangement of gas piping serving a building, structure or premises, whether individually metered or not.

HIGH-DISTRIBUTION PRESSURE or **SECOND-STATE PRESSURE** (used in liquefied petroleum gas systems) is pressure exceeding 14 inches water column but not exceeding 20 psig.

LIQUEFIED PETROLEUM GAS FACILITIES are tanks, containers, container valves, regulating equipment, meters and appurtenances for the storage and supply of liquefied petroleum gas for a building or premises.

MEDIUM PRESSURE is pressure exceeding 14 inches water column but not exceeding 5 psig.

PIPELINE WELDER is a person qualified in welding pipes who holds a valid certificate of competency from an approved agency based on demonstrated ability in meeting the requirements of Section IX of the ASME Boiler and Pressure Vessel Code.

QUICK-DISCONNECT DEVICE is a hand-operated device which provides a means for connecting and disconnecting an appliance or an appliance connector to a gas supply. The device is equipped with an automatic means to shut off the gas supply when the device is disconnected.

SERVICE PIPING is the piping and equipment between the street gas main and the gas-piping system inlet which is installed by and is under the control and maintenance of the serving gas supplier.

Permit

Sec. 2203. A permit shall be obtained prior to installation, removal, alteration or repair of fuel-gas piping systems as required by the provisions of Chapter 3 of this code.

Plans Required

Sec. 2204. The building official may require submission of plans, specifications, drawings and such other information as deemed necessary prior to the commencement of and at any time during the progress of work regulated by this chapter.

Workmanship

Sec. 2205. Gas piping shall not be strained or bent nor shall appliances be supported by or develop strain or stress on supply piping. Gas piping supplying appliances designed to be supported by the piping may be used to support appliances.

Inspections

Sec. 2206. (a) **General.** Upon completion of installation, alteration or repair of gas piping, and prior to the use thereof, the building official shall be notified that gas piping is ready for inspection.

(b) **Accessibility for Inspection.** Excavations required for the installation of underground piping shall be kept open until such time as the piping has been inspected and approved. If piping is covered or concealed before approval, it shall be exposed upon the direction of the building official.

(c) **Required Inspections.** The building official shall make the following inspections and shall either approve that portion of the work as completed, or shall notify the permit holder wherein the same fails to comply with this chapter.

1. **Rough piping inspection.** This inspection shall be made after gas piping authorized by the permit has been installed and before such piping has been covered or concealed or a fixture or appliance has been attached thereto. This inspection shall include a determination that the gas piping size, material and installation meet the requirements of this chapter.

2. **Final piping inspection.** This inspection shall be made after piping authorized by the permit has been installed and after all portions thereof which are to be covered or concealed are so concealed and before fixtures, appliances or shutoff valves have been attached thereto.

This inspection shall include an air, CO_2 or nitrogen pressure test, at which time the gas piping shall stand a pressure of not less than 10-pounds-per-square-inch gage, or, at the discretion of the building official, the piping and valves may be tested at a pressure of at least 6 inches mercury, measured with a manometer or slope gage. Test pressures shall be held for a length of time satisfactory to the building official but not less than 15 minutes, with no perceptible drop in pressure. For welded piping, and for piping carrying gas at pressures exceeding 14 inches water column pressure, the test pressure shall be at least 60 pounds per square inch and shall be continued for a length of time satisfactory to the building official but not less than 30 minutes. These tests shall be made using air, CO_2 or nitrogen pressure only and shall be made in the presence of the building official. Necessary apparatus for conducting tests shall be furnished by the permit holder.

(d) **Other Inspections.** In cases where the work authorized by the permit consists of a minor installation of additional piping to piping already connected to a gas meter, the foregoing inspections may be waived at the discretion of the building official. The building official shall make such inspection as he deems advisable in order to assure that the work has been performed in accordance with the intent of this chapter.

Certificate of Inspection

Sec. 2207. If, upon final piping inspection, the installation is found to comply with the provisions of this chapter, a certificate of inspection may be issued by the building official.

A copy of the certificate of final piping inspection shall be issued to the serving gas supplier supplying gas to the premises.

It shall be unlawful for a serving gas supplier, or person furnishing gas, to turn on, or cause to be turned on, fuel gas or gas meters, until the certificate of final inspection, as herein provided, has been issued.

Authority to Render Gas Service

Sec. 2208. It shall be unlawful for a person, firm or corporation, excepting an authorized agent or employee of a person, firm or corporation engaged in the business of furnishing or supplying gas and whose service pipes supply or connect with the particular premises, to turn on or reconnect gas service in or on a premises where and when gas service is, at the time, not being rendered.

It shall be unlawful to turn on or connect gas in or on a premises unless gas piping outlets are properly and securely connected to gas appliances or capped or plugged with threaded fittings.

Authority to Disconnect

Sec 2209. (a) **General.** The building official or the serving gas supplier is authorized to disconnect any gas piping or appliance, or both, which is found not to conform to the requirements of this chapter or which is found defective and a danger to life or property.

(b) **Disconnection Notice.** A notice of disconnection shall be attached to defective piping and appliances stating why they have been disconnected.

(c) **Closing Outlets.** It shall be unlawful to remove or disconnect gas piping or a gas appliance without capping or plugging the outlet from which said pipe or appliance was removed with a threaded fitting. Outlets on a piping system which has been installed, altered or repaired to which gas appliances are not connected shall be left capped gastight.

> **EXCEPTION:** When an approved listed quick-disconnect device is installed.

Temporary Use of Gas

Sec. 2210. The building official may allow temporary use of fuel gas from a gas-piping system conforming to the requirements of this chapter. The period of temporary use shall be established by the building official.

Gas Meter Locations.

Sec. 2211. (a) **General.** Gas meter locations shall be approved by the building official and the serving gas supplier.

(b) **Multiple Meters.** When more than one meter is set on a premises, they shall all be set at one location, except when this is impractical. In multiple meter installations, each gas-piping system shall be identified by the permittee in a manner satisfactory to the building official and the serving gas supplier.

(c) **Main Shutoff.** Gas meters shall be preceded by a main supply shutoff valve and shall be so placed as to be readily accessible for inspection, reading, testing and shutting off the gas supply. Service piping and main supply shutoff valves shall be outside of the building and readily accessible.

(d) **Inlet Location.** The gas piping inlet shall be located adjacent to the approved meter location.

(e) **Meter Access.** Access to enclosed gas meters, except those located in an approved vault supplied by the serving gas supplier, shall be through an opening or door not less in size than 22 inches by 24 inches.

(f) **Meter Location.** Gas meters shall not be located under a show window or under interior stairways or in engine, boiler, heater or electric meter rooms. Where not prohibited by other regulations, gas meters may be located in the open under exterior stairways.

Material for Gas Piping

Sec. 2212. Pipe used for the installation, extension, alteration or repair of gas piping shall be standard weight wrought iron or steel (galvanized or black), yellow brass containing not more than 75 percent copper, or internally tinned or equivalently treated copper of iron pipe size. Approved PVC or PE pipe may be used in exterior buried piping systems.

Gas pipe shall be new or shall have been used previously for no purpose other than conveying gas; it shall be in good condition, clean and free from internal obstructions. Burred ends shall be reamed to the full bore of the pipe.

Fittings used in connection with the piping shall be of malleable iron, yellow brass containing not more than 75 percent copper or approved plastic fittings.

Valves and appurtenances for gas piping shall be of a type designed and approved for use with fuel gas.

Installation of Gas Piping

Sec 2213. (a) **Joints.** Joints in the piping system, unless welded, shall be threaded joints having approved standard threads. Threaded joints shall be made with approved pipe joint material, insoluble in fuel gas and applied to the male threads only. Welded joints in a gas-supply system shall be made by a pipeline welder. See Section 2202.

(b) **Location.** Gas piping shall not be installed in or on the ground under any building or structure and exposed gas piping shall be kept at least 6 inches above grade or structure.

Concealed unprotected gas piping may be installed above grade in approved recesses or channels.

> **EXCEPTION:** When necessary due to structural conditions, approved type gas piping may be installed in other locations, when permission has first been obtained from the building official.

(c) **Drip Pipes.** When water vapor is present in the fuel gas served, accessible drip pipes shall be provided at points where condensation will collect.

(d) **Corrosion and Covering Protection.** Ferrous gas piping installed underground in exterior locations shall be protected from corrosion by approved coatings or wrapping materials applied in an approved manner. Horizontal metallic piping shall have at least 12 inches of earth cover or equivalent protection. Plastic gas piping shall have at least 18 inches of earth cover or equivalent protection. Risers, including prefabricated risers inserted with plastic pipes, shall be metallic and shall be protected in an approved manner to a point at least 6 inches above grade. When a riser connects to plastic pipe underground the horizontal metallic portion underground shall be at least 30 inches in length before connecting to the plastic service pipe. An approved transition fitting or adaptor shall be used where the plastic joins the metallic riser.

Gas pipe protective coatings shall be approved types, machine applied conforming to recognized standards. Field wrapping shall provide equivalent protection and is restricted to those short sections and fittings necessarily stripped for threading or welding. Zinc coatings (galvanizing) shall not be deemed adequate protection for piping below ground. Ferrous metals exposed in exterior locations shall be protected from corrosion in a manner satisfactory to the building official.

(e) **Corrosion Isolation.** Underground ferrous gas piping shall be electrically isolated from the rest of the gas system with listed or approved isolation fittings installed a minimum of 6 inches above grade.

(f) **Support and Fill.** Gas piping shall be adequately supported by metal straps or hooks at intervals not to exceed those shown in Table No. 22-A. Gas piping installed below grade shall be effectively supported at all points on undisturbed or well-compacted soil or sand.

(g) **Building Shutoff.** Gas piping supplying more than one building on a premises shall be equipped with separate shutoff valves to each building, so arranged that the gas supply can be turned on or off to an individual or separate building. The shutoff valve shall be located outside the building it supplies and shall be readily accessible. Buildings accessory to single-family residences are exempt from the requirements of this subsection.

(h) **Unions.** Where unions are necessary, right and left nipples and couplings shall be used. Ground-joint unions may be used at exposed fixture, appliance or equipment connections and in exposed exterior locations immediately on the discharge side of a building shutoff valve. Heavy-duty flanged-type unions may be used in special cases, when approved by the building official. Bushings shall not be in concealed locations.

(i) **Interjections.** When air, oxygen or other special supplementary gas under pressure is introduced with the regularly supplied gas, either directly into the gas-piping system or at burners, a device approved by the building official shall be installed to prevent backflow of the supplemental gas into the gas-piping system. The device shall be located between the source of the supplemental gas and meter and shall be on the gas line leading to the appliance using the special gas. This device may be either a spring-loaded or diaphragm-type check valve and shall be capable of withstanding the pressure imposed on it.

When liquefied petroleum or other standby gas is interconnected with the regular gas-piping system, an approved three-way two-port valve or other adequate safeguard acceptable to the building official shall be installed to prevent backflow into either supply system.

(j) **Valves.** Valves used in connection with gas piping shall be approved types.

(k) **Barbecue or Fireplace Outlets.** Gas outlets in a barbecue or fireplace shall be controlled by an approved operating valve located in the same room and outside the fireplace but not more than 4 feet from the outlets. If piping on the discharge side of the control valve is standard weight brass or galvanized steel, the piping may be embedded in or surrounded by not less than 2 inches of concrete or masonry.

(l) **Shutoff Valve.** An accessible shutoff valve of a type set forth in Subsection (j) of this section shall be installed in the fuel-supply piping outside of each appliance and ahead of the union connection thereto, and in addition to any valve on the appliance. Shutoff valves shall be within 3 feet of the appliance.

Shutoff valves may be located immediately adjacent to and inside or under an appliance when placed in an accessible and protected location and when such appliance may be removed without removal of the valve.

Shutoff valves may be accessibly located inside wall heaters and wall furnaces listed for recessed installation where necessary maintenance can be performed without removal of the shutoff valve.

(m) **Tracer for Nonmetallic Buried Piping.** A No. 18 copper tracer wire or other approved conductor shall be installed with and attached to underground nonmetallic gas piping and shall terminate above grade at each end.

(n) **Directional Changes.** Changes in direction of gas piping shall be made by use of appropriate fittings, except that polyethylene gas piping and tubing may be bent to a radius not less than 20 times the nominal diameter of the pipe or tube.

Appliance Fuel Connectors

Sec. 2214. Appliance connections shall have a diameter not less than that of the inlet connection to the appliance as provided by the manufacturer and each appliance shall be rigidly connected to the gas piping with materials as provided in Section 2212.

> **EXCEPTION:** A gas appliance may be connected with an approved listed metal appliance connector under the following conditions:
>
> 1. Listed metal appliance connectors shall have an overall length not to exceed 3 feet, except range and domestic clothes dryer connectors, which may not exceed 6 feet.
> 2. Connectors shall not be concealed within or extended through wall, floor or partition.
> 3. A listed appliance connector valve not less than the nominal size of the connector shall be accessible at the gas piping outlet immediately ahead of the connector.
> 4. Connectors shall be of adequate size to provide the total demand of the connected appliance based on Table No. 22-B-1 or 22-B-2 as applicable.
> 5. Aluminum alloy connectors may be used only in interior locations where they shall not be in contact with masonry, plaster or insulation or are not subject to repeated corrosive wettings.
> 6. The connection of an indoor appliance with any type of gas hose is prohibited, except when used for laboratory or shop equipment or equipment that requires mobility during operation. Such connections shall have the shutoff or stopcock installed at the connection to the building piping. When gas hose is used, it shall be of the minimum practical length, but not to exceed 6 feet, except for hand torches and special mobile equipment, and shall not extend from one room to another nor pass through walls, partitions, ceilings or floors. Gas hose shall not be concealed from view or used in a concealed location. Only listed gas hose shall be used in accordance with its listing. Gas hose shall not be used where it is likely to be subject to temperatures exceeding 125°F., nor shall it be used as a substitute for a standard appliance connector.
> 7. Outdoor portable appliances may be connected with an approved outdoor hose connector not to exceed 15 feet in length, provided it connects outdoors to approved gas piping including an approved valve at the inlet of the hose connector.
> 8. Appliances may be connected to fuel-gas piping with an approved listed quick-disconnect device.

Liquefied Petroleum Gas Facilities and Piping

Sec. 2215. In addition to the requirements of this chapter for gas piping, the facilities and piping for use with liquefied petroleum gas shall meet the following requirements:

Liquefied petroleum gas facilities shall conform to approved standards. Liquefied petroleum gas facilities and their locations shall be approved by the building official and shall conform to state and local fire-prevention regulations.

When liquefied petroleum gas facilities serve more than one customer through separate piping systems, each system shall be identified in a manner satisfactory to the building official.

Liquefied petroleum gas facilities shall be so placed as to be readily accessible for inspection, reading, testing and shutting off the gas supply. Service piping and main supply shutoff valves shall be outside of the building. Main supply valves shall be of approved type and readily accessible.

Gas piping inlets shall be located with respect to the proposed liquefied petroleum gas facility location in accordance with the requirements of this section.

Liquefied petroleum gas facilities shall not be located in a pit or basement, under show windows or interior stairways, in engine, boiler, heater or electric meter rooms. When not prohibited by another regulation, approved liquefied petroleum gas metering devices may be located in the open under exterior stairways.

Liquefied petroleum gas piping shall not serve appliances located in a pit or basement where heavier-than-air gas might collect to form a flammable mixture.

Pipe-joint compounds used on threaded connections shall be insoluble in liquefied petroleum gas.

Valves and appurtenances used in liquefied petroleum gas systems shall be designed and approved for use with liquefied petroleum gas.

Discharge from relief valves shall be into open air and shall be at least 5 feet measured horizontally from an opening into a building which is below the discharge.

Leaks

Sec. 2216. Leaks in gas piping shall be located by applying soapy water to the exterior of the piping.

Flame or acid shall not be used to locate or repair leaks, nor shall substances other than air be introduced into the gas piping.

Defective pipe or fitting shall be removed and replaced with sound material when found.

Interconnections of Gas Piping Systems

Sec. 2217. It shall be unlawful to connect a gas appliance in such a manner that the appliance may receive gas from more than one system of gas piping.

The installation, use or maintenance of a gas valve which makes it possible to turn on, control or otherwise direct the flow of gas from one system of gas piping to another, where the systems are supplied with gas from separate meters, is prohibited, and valves or other interconnection between separate systems of gas piping shall be removed upon order of the building official.

Required Gas Supply

Sec. 2218. (a) **General.** Natural gas regulations and tables are based on the use of gas having a specific gravity of 0.60 supplied at 6 to 8 inches water column pressure at the outlet of the meter. For undiluted liquefied petroleum gas, gas piping may be sized for 2500 Btu per cubic foot at 11 inches water column and specific gravity of 1.52.

Where gas of a different specific gravity is to be delivered, the serving gas supplier should be contacted for conversion factors or revised capacity tables to use in sizing piping systems.

(b) **Determining Volume.** The hourly volume of gas required at each piping outlet shall be taken as not less than the maximum hourly rating as specified by the manufacturer of the appliance or appliances to be connected to each such outlet.

When gas appliances to be installed have not been definitely specified, Table No. 22-C may be used to estimate requirements of typical appliances.

To obtain the cubic feet per hour of gas required, divide Btu per hour input of appliances by the average Btu heating value per cubic foot of the gas. The average Btu per cubic foot of the gas in the area of the installation may be obtained from the serving gas supplier.

(c) **Minimum Size.** The size of the supply piping outlet for a gas appliance shall be at least 1/2 inch.

The minimum size piping outlet for a mobile home shall be 3/4 inch.

Required Gas Piping Size

Sec. 2219. (a) **General.** When the maximum demand does not exceed 250 cubic feet per hour and the maximum length of piping between the meter and the most distant outlet does not exceed 250 feet, the size of each section and each outlet of any system of gas piping shall be determined by using Table No. 22-D. Other systems within the range of Table No. 22-D may be sized from that table or by the methods set forth in Subsection (b) of this section.

To determine the size of each section of pipe in a system within the range of Table No. 22-D, proceed as follows:

1. Measure the length of the pipe from the gas meter location to the most remote outlet on the system.
2. In Table No. 22-D, select the column showing that distance, or the next longer distance, if the table does not give the exact length.
3. Starting at the most remote outlet, find in the vertical column just selected, the gas demand for that outlet. If the exact figure of demand is not shown, choose the next larger figure below in the column.
4. Opposite this demand figure, in the first column at the left in Table No. 22-D, will be found the correct size of pipe.
5. Using this same vertical column, proceed in a similar manner for each section of pipe serving this outlet. For each section of pipe, determine the total gas demand supplied by that section. Where gas piping sections serve both heating and cooling equipment and the installation prevents both units from operating simultaneously, only the larger of the two demand loads need be used in sizing these sections.
6. Size each section of branch piping not previously sized by measuring the distance from the gas meter location to the most remote outlet in that branch and follow the procedures of steps 2, 3, 4 and 5 above. **Note:** Size branch piping in the order of their distance from the meter location, beginning with the most distant outlet not previously sized.

(b) **High Demands and Long Runs.** For conditions other than those covered by Subsection (a) of this section, such as longer runs or greater gas demands, the size of each gas-piping system shall be determined by standard engineering methods acceptable to the building official and each system shall be so designed that the total pressure drop between the meter or other point of supply and any outlet when full demand is being supplied to all outlets will not exceed 0.5-inch water column pressure.

(c) **Other Systems.** When the gas pressure is higher than 14 inches or lower than 6 inches water column, or when diversity demand factors are used, the design, pipe, sizing, materials, location and use of such systems shall be approved by the building official. Piping systems designed for pressures higher than the serving gas supplier's standard delivery pressure shall have prior verification from the gas supplier of the availability of the design pressure. Systems using undiluted liquefied petroleum gas may be sized using Table No. 22-E for 11 inches water column and in accordance with the provisions of Subsections (a) and (b).

Medium- and High-pressure Gas Piping

Sec. 2220. (a) **General.** Approval of the building official and verification from the serving gas supplier of the availability of the desired pressure shall be obtained before any medium- or high-pressure gas-piping system is installed.

(b) **Applicability.** The following requirements shall apply to medium-pressure gas-piping systems.

(c) **Pressure Regulators.** Approved regulators shall be installed on medium- and high-pressure gas-piping systems, in approved locations, and shall be accessible for servicing. Each regulator shall have a separate vent to the outside.

> **EXCEPTION:** Pounds-to-inches water-column regulators equipped with limiting orifices capable of releasing not more than 5 cubic feet of gas per hour when supplied with medium pressure need not be vented to an outside location when the regulators have been approved by the building official. These regulators shall:
>
> 1. Be connected to the same piping material used to pipe the structure. A listed gas connector may be used to attach the low-pressure piping downstream of the regulator to the appliance manifold.
> 2. Have an approved gas valve in the supply line upstream of the pounds-to-inches water-column regulator.
> 3. Be accessible.
> 4. Have the upstream pressure identified. Such identification shall be a metal tag permanently attached to the regulator and state: Warning 1/2 to 5 pounds natural gas pressure. DO NOT REMOVE.
> 5. Be installed in a location that communicates with a ventilated area.

An approved gas valve shall be installed immediately preceding each regulator. Regulators that may be subjected to mechanical damage shall be substantially protected to the satisfaction of the building official.

(d) **Three or 5 psig.** Tables Nos. 22-F and 22-G may be used to size a natural-gas piping system carrying 3 or 5 psig gas. The procedure to determine the size of each section of the system is similar to that contained in Section 2219 using the pipe length from the meter to the most remote regulator on the medium-pressure system and sizing the downstream low-pressure piping from Table No. 22-D.

(e) **Ten psig.** Table No. 22-H may be used to size undiluted liquefied petroleum gas-piping systems carrying 10 psig gas. The procedure to determine the size of each section of the system is similar to Section 2219 using the pipe length from the first stage or tank regulator to the most remote regulator in the second-state system. Low-pressure piping shall be sized from Table No. 22-E.

(f) **Corrosion and Cover Protection.** Buried medium pressure gas piping shall be protected from corrosion as required by Section 2213 and shall have a minimum earth cover of 18 inches. Piping shall be covered with at least 6 inches of hand-placed selected backfill devoid of rocks, building materials or other matter that may damage the pipe or wrapping.

Fuel-gas Equipment and Installations in Mobile-home Parks

Sec. 2221. (a) **General.** Except as otherwise permitted or required by this section, fuel-gas equipment and installations in mobile home parks shall comply with the provisions of this chapter. The provisions of this section do not apply to the mobile home gas piping and equipment.

(b) **Required Gas Supply.** The minimum hourly volume of gas required at each mobile home lot outlet or any section of the mobile home park gas-piping system shall be calculated as shown in Table No. 22-I.

Required gas supply for buildings or other fuel-gas-consuming appliances connected to the mobile home park gas-piping system shall be calculated as provided in this chapter.

(c) **Installation.** Gas piping installed belowground shall have a minimum earth cover of 18 inches.

Gas piping shall not be installed aboveground under a mobile home.

(d) **Location.** Gas piping shall not be installed underground beneath buildings or that portion of the mobile home lots reserved for the location of mobile homes, mobile home accessory buildings or structures, concrete slabs or automobile parking, unless installed in a gastight conduit.

The conduit shall be pipe approved for installation underground beneath buildings and not less than Schedule 40 pipe. The interior diameter of the conduit shall be at least 1/2 inch larger than the outside diameter of the gas piping.

The conduit shall extend to a point at least 12 inches beyond any area where it is required, or the outside wall of a building, and the outer ends shall not be sealed. When the conduit terminates within a building, it shall be readily accessible and the space between the conduit and the gas piping shall be sealed to prevent leakage of gas into the building.

A gas piping lateral terminating in a mobile home lot outlet riser surrounded by a concrete slab shall not be required to be installed in a conduit provided the concrete slab is entirely outside the wall line of the mobile home, is not continuous with any other concrete slab and is used for stabilizing other utility connections.

(e) **System Shutoff Valve.** A readily accessible and identified shutoff valve controlling the flow of gas to the entire gas-piping system shall be installed near the point of connection to the service piping or supply connection of the liquefied petroleum gas tank.

(f) **Mobile Home Lot Shutoff Valve.** Each mobile home lot shall have an approved gas shutoff valve installed upstream of the mobile home lot gas outlet and located on the outlet riser at a height at least 4 inches above grade. Such valve shall not be located under a mobile home. When the mobile home lot outlet is not in use, the outlet shall be equipped with an approved cap or plug to prevent accidental discharge of gas.

(g) **Mobile Home Lot Gas Outlet.** Each mobile home lot piped for gas shall be provided with an individual outlet riser at the mobile home lot.

The mobile home lot gas outlet shall terminate with the service connection located within a 4-foot area in the rear third section of the mobile home lot on the left (road) side of the mobile home, with respect to the location, or proposed location, of the mobile home on the lot.

(h) **Mobile Home Connector.** Each mobile home shall be connected to the mobile home lot outlet by an approved mobile home connector, a maximum of 6 feet in length. Approved pipe and fittings may be used between the flexible connector and the mobile home lot gas outlet when the distance between the mobile home lot gas outlet and the mobile home gas service connection exceeds that required to make a safe installation with only a mobile home connector. Gas connectors shall be of a size to adequately supply the total demand of the connected mobile home.

(i) **Mechanical Protection.** Gas outlet risers, regulators, meters, valves or other exposed equipment shall be protected from mechanical damage by vehicles or other causes. Such protection may consist of posts, fencing or other permanent barriers.

Atmospherically controlled regulators shall be installed in a manner that moisture cannot enter the regulator vent and accumulate above the diaphragm. When the regulator vent may be obstructed by snow or ice, shields, hoods or other suitable devices shall be provided to guard against obstruction of the vent opening.

(j) **Gas Meters.** Meters shall be installed in ventilated or accessible locations, not closer than 3 feet to sources of ignition.

When meters are installed, they shall not depend on the gas outlet riser for support, but shall be adequately supported by a post or bracket placed on a firm footing, or other approved means providing equivalent support.

(k) **Gas Piping Size.** The size of each section of natural gas or LP-gas piping systems shall be determined as specified in this chapter.

(l) **Maintenance.** The operator of the mobile home park shall be responsible for maintaining gas piping installations and equipment in a safe working condition.

TABLE NO. 22-A—SUPPORT OF PIPING

SIZE OF PIPE (Inches)	FEET
1/2″	6
3/4″ or 1″	8
1 1/4″ or larger (horizontal)	10
1 1/4″ or larger (vertical)	Every floor level

TABLE NO. 22-B-1— CAPACITIES OF LISTED METAL APPLIANCE CONNECTORS[1]

For use with gas pressure 8-inch or more water column

SEMI-RIGID CONNECTOR O.D.[2] (Inch)	FLEXIBLE CONNECTOR NOMINAL I.D.[3] (Inch)	MAXIMUM CAPACITIES IN THOUSANDS Btu/h (Based on pressure drop of 0.4-inch water column) Natural Gas[4] of 1100 Btu/cu. ft.							
		All Gas Appliances					Ranges and Domestic Clothes Dryers Only		
		1-foot	1 1/2-foot	2-foot	2 1/2-foot	3-foot	4-foot	5-foot	6-foot
3/8	1/4	40	33	29	27	25	101	90	80
1/2	3/8	93	76	66	62	58			
5/8	1/2	189	155	134	125	116			
	3/4	404	330	287	226	244			
	1	803	661	573	534	500			

[1] Gas connectors are certified by the testing agency as complete assemblies including fittings and valves. Capacities shown are based on the use of fittings and valves supplied with the connector.

[2] Outside diameter.

[3] Internal diameter.

[4] For liquefied petroleum gas use 1.6 times the natural gas capacities shown.

TABLE NO. 22-B-2— CAPACITIES OF LISTED METAL APPLIANCE CONNECTORS[1]

For use with gas pressures less than 8-inch water column

SEMI-RIGID CONNECTOR O.D.[2] (Inch)	FLEXIBLE CONNECTOR NOMINAL I.D.[3] (Inch)	CAPACITIES FOR VARIOUS LENGTHS IN THOUSANDS Btu/h (Based on pressure drop of 0.2-inch water column) Natural Gas[4] of 1100 Btu/cu. ft.							
		All Gas Appliances					Ranges and Domestic Clothes Dryers Only		
		1-foot	1 1/2-foot	2-foot	2 1/2-foot	3-foot	4-foot	5-foot	6-foot
3/8	1/4	28	23	20	19	17	72	63	57
1/2	3/8	66	54	47	44	41			
5/8	1/2	134	110	95	88	82			
	3/4	285	233	202	188	174			
	1	567	467	405	378	353			

[1] Gas connectors are certified by the testing agency as complete assemblies including fittings and valves. Capacities shown are based on the use of fittings and valves supplied with the connector.

[2] Semirigid connector listings are based on outside diameter.

[3] Flexible connector listings are based on nominal diameter.

[4] For liquefied petroleum gas use 1.6 times the natural gas capacities shown.

TABLE NO. 22-C—MINIMUM DEMAND OF TYPICAL GAS APPLIANCES
Btu/h

APPLIANCE	DEMAND
Domestic gas range	65,000
Domestic recessed top burner section	40,000
Domestic recessed oven section	25,000
Storage water heater—up to 30-gal. tank	30,000
Storage water heater—40 to 50-gal. tank	50,000
Domestic clothes dryer	35,000
Fireplace log lighter (residential)	25,000
Fireplace log lighter (commercial)	50,000
Barbecue (residential)	50,000
Gas refrigerator	3,000
Bunsen burner	3,000
Mobile homes	[1]
Gas engines (per horsepower)	10,000
Steam boilers (per horsepower)	50,000

[1] See Table No. 22-I

TABLE NO. 22-D—SIZE OF GAS PIPING

Maximum Delivery Capacity in Cubic Feet of Gas Per Hour of I.P.S. Pipe Carrying Natural Gas of 0.60 Specific Gravity Based on 0.5-inch Water Column Pressure Drop

PIPE SIZE (In Inches)	(Length in Feet)										
	10′	20′	30′	40′	50′	60′	70′	80′	90′	100′	125′
1/2	174	119	96	82	73	66	61	56	53	50	44
3/4	363	254	200	171	152	138	127	118	111	104	93
1	684	470	377	323	286	259	239	222	208	197	174
1 1/4	1,404	965	775	663	588	532	490	456	428	404	358
1 1/2	2,103	1,445	1,161	993	880	798	734	683	641	605	536
2	4,050	2,784	2,235	1,913	1,696	1,536	1,413	1,315	1,234	1,165	1,033
2 1/2	6,455	4,437	3,563	3,049	2,703	2,449	2,253	2,096	1,966	1,857	1,646
3	11,412	7,843	6,299	5,391	4,778	4,329	3,983	3,983	3,476	3,284	2,910
3 1/2	16,709	11,484	9,222	7,893	6,995	6,338	5,831	5,425	5,090	4,808	4,261
4	23,277	15,998	12,847	10,995	9,745	8,830	8,123	7,557	7,090	6,698	5,936
	150′	200′	250′	300′	350′	400′	450′	500′	550′	600′	
1/2	40	34	30	28	25	24	22	21	20	19	
3/4	84	72	64	58	53	49	46	44	42	40	
1	158	135	120	109	100	93	87	82	78	75	
1 1/4	324	278	246	223	205	191	179	169	161	153	
1 1/2	486	416	369	334	309	286	268	253	241	230	
2	936	801	710	643	592	551	517	488	463	442	
2 1/2	1,492	1,277	1,131	1,025	943	877	823	778	739	705	
3	2,637	2,257	2,000	1,812	1,667	1,551	1,455	1,375	1,306	1,246	
3 1/2	3,861	3,304	2,929	2,654	2,441	2,271	2,131	2,013	1,912	1,824	
4	5,378	4,603	4,080	3,697	3,401	3,164	2,968	2,804	2,663	2,541	

TABLE NO. 22-E—MAXIMUM CAPACITY OF PIPE IN THOUSANDS OF Btu/h OF UNDILUTED LIQUEFIED PETROLEUM GASES

For Distribution Pressure of 11-Inch Water Column, Pressure Drop of 0.5-Inch Water Column

NOMINAL IRON PIPE SIZE (In Inches)	LENGTH OF PIPE, FEET												
	10	20	30	40	50	60	70	80	90	100	125	150	200
½	275	189	152	129	114	103	96	89	83	78	69	63	55
¾	567	393	315	267	237	217	196	185	173	162	146	132	112
1	1071	732	590	504	448	409	378	346	322	307	275	252	213
1¼	2205	1496	1212	1039	913	834	771	724	677	630	567	511	440
1½	3307	2299	1858	1559	1417	1275	1181	1086	1023	976	866	787	675
2	6221	4331	3465	2992	2646	2394	2205	2047	1921	1811	1606	1496	1260

TABLE NO. 22-F—MEDIUM-PRESSURE NATURAL GAS SYSTEM

For Sizing Gas Piping Systems Carrying Gas of 0.60 Specific Gravity Capacity of Pipes of Different Diameters and Lengths in Cubic Feet per Hour for Gas Pressure of 3.0 psi with a Drop to 1.5 psi

PIPE SIZE (In Inches)	LENGTH OF PIPE (In Feet)											
	50′	100′	150′	200′	250′	300′	350′	400′	450′	500′	550′	600′
1/2	857	589	473	405	359	325	299	278	261	247	234	224
3/4	1,793	1,232	990	847	751	680	626	582	546	516	490	467
1	3,377	2,321	864	1,595	1,414	1,281	1,179	1,096	1,029	972	923	881
1 1/4	6,934	4,766	3,827	3,275	2,903	2,630	2,420	2,251	2,112	1,995	1,895	1,808
1 1/2	10,389	7,140	5,734	4,908	4,349	3,941	3,626	3,373	3,165	2,989	2,839	2,709
2	20,008	13,752	11,043	9,451	8,377	7,590	6,983	6,496	6,095	5,757	5,468	5,216
2 1/2	31,890	21,918	17,601	15,064	13,351	12,097	11,129	10,353	9,714	9,176	8,715	8,314
3	56,376	38,747	31,115	26,631	23,602	21,385	19,674	18,303	17,173	16,222	15,406	14,698
	650′	700′	750′	800′	850′	900′	950′	1000′	1100′	1200′	1300′	1400′
1/2	214	206	198	191	185	180	174	170	161	154	147	141
3/4	448	430	414	400	387	375	365	355	337	321	308	296
1	843	810	780	754	729	707	687	668	634	605	580	557
1 1/4	1,731	1,663	1,602	1,547	1,497	1,452	1,410	1,371	1,302	1,242	1,190	1,143
1 1/2	2,594	2,492	2,401	2,318	2,243	2,175	2,112	2,055	1,951	1,862	1,783	1,713
2	4,995	4,799	4,623	4,465	4,321	4,189	4,068	3,957	3,758	3,585	3,433	3,298
2 1/2	7,962	7,649	7,369	7,116	6,886	6,677	6,484	6,307	5,990	5,714	5,472	5,257
3	14,075	13,522	13,027	12,580	12,174	11,803	11,463	11,149	10,589	10,102	9,674	9,294
4	28,709	27,581	26,570	25,658	24,831	24,074	23,380	22,741	21,598	20,605	19,731	18,956
	1500′	1600′	1700′	1800′	1900′	2000′	2100′	2200′	2300′	2400′	2500′	2600′
1/2	136	131	127	123	120	117	114	111	108	106	103	101
3/4	285	275	266	258	251	244	237	231	226	221	216	211
1	536	518	501	486	472	459	447	436	426	416	407	398
1 1/4	1,101	1,063	1,029	998	969	942	918	895	874	854	835	818
1 1/2	1,650	1,593	1,542	1,495	1,452	1,412	1,375	1,341	1,309	1,279	1,252	1,225
2	3,178	3,069	2,970	2,879	2,796	2,720	2,649	2,583	2,522	2,464	2,410	2,360
2 1/2	5,064	4,891	4,733	4,589	4,457	4,335	4,222	4,117	4,019	3,927	3,842	3,761
3	8,953	8,646	8,367	8,112	7,878	7,663	7,463	7,278	7,105	6,943	6,791	6,649
4	18,262	17,635	17,066	16,546	16,069	15,629	15,222	14,844	14,491	14,161	13,852	13,561
5	33,038	31,904	30,875	29,935	29,072	28,276	27,539	26,855	26,217	25,620	25,060	24,534
6	53,496	51,660	49,993	48,471	47,074	45,785	44,593	43,484	42,451	41,485	40,579	39,727

TABLE NO. 22-G—MEDIUM-PRESSURE NATURAL GAS SYSTEM

For Sizing Gas Piping Systems Carrying Gas of 0.60 Specific Gravity Capacity of Pipes of Different Diameters and Lengths in Cubic Feet per Hour for Gas Pressure of 5.0 psi with a Drop to 1.5 psi

PIPE SIZE (In Inches)	LENGTH OF PIPE (In Feet)											
	50′	100′	150′	200′	250′	300′	350′	400′	450′	500′	550′	600′
1/2	1,399	961	772	661	586	531	488	454	426	402	382	365
3/4	2,925	2,010	1,614	1,381	1,224	1,109	1,021	949	891	842	799	762
1	5,509	3,786	3,041	2,602	2,306	2,090	1,923	1,789	1,678	1,585	1,506	1,436
1 1/4	11,311	7,774	6,243	5,343	4,735	4,291	3,947	3,672	3,445	3,255	3,091	2,949
1 1/2	16,947	11,648	9,353	8,005	7,095	6,429	5,914	5,502	5,162	4,876	4,631	4,418
2	32,638	22,432	18,014	15,417	13,664	12,381	11,390	10,596	9,942	9,391	8,919	8,509
2 1/2	52,020	35,753	28,711	24,573	21,779	19,733	18,154	16,889	15,846	14,968	14,216	13,562
3	91,962	63,205	50,756	43,441	38,501	34,884	32,093	29,856	28,013	26,461	25,131	23,976
	650′	700′	750′	800′	850′	900′	950′	1000′	1100′	1200′	1300′	1400′
1/2	349	335	323	312	302	293	284	277	263	251	240	231
3/4	730	701	676	653	632	612	595	578	549	524	502	482
1	1,375	1,321	1,273	1,229	1,190	1,153	1,120	1,089	1,035	987	945	908
1 1/4	2,824	2,713	2,614	2,524	2,442	2,368	2,300	2,237	2,124	2,027	1,941	1,865
1 1/2	4,231	4,065	3,916	3,781	3,659	3,548	3,446	3,351	3,183	3,037	2,908	2,794
2	8,149	7,828	7,542	7,283	7,048	6,833	6,636	6,455	6,130	5,848	5,600	5,380
2 1/2	12,988	12,477	12,020	11,608	11,233	10,891	10,577	10,288	9,771	9,321	8,926	8,575
3	22,960	22,057	21,249	20,520	19,858	19,253	18,698	18,187	17,273	16,478	15,780	15,160
4	46,830	44,990	43,342	41,855	40,504	39,271	38,139	37,095	35,231	33,611	32,186	30,921
	1500′	1600′	1700′	1800′	1900′	2000′	2100′	2200′	2300′	2400′	2500′	2600′
1/2	222	214	208	201	195	190	185	181	176	172	168	165
3/4	464	449	434	421	409	398	387	378	369	360	352	345
1	875	845	818	793	770	749	729	711	694	678	664	650
1 1/4	1,796	1,735	1,679	1,628	1,581	1,537	1,497	1,460	1,425	1,393	1,363	1,334
1 1/2	2,691	2,599	2,515	2,439	2,368	2,303	2,243	2,188	2,136	2,087	2,042	1,999
2	5,183	5,005	4,844	4,696	4,561	4,436	4,321	4,213	4,113	4,020	3,932	3,849
2 1/2	8,261	7,978	7,720	7,485	7,270	7,071	6,886	6,715	6,556	6,406	6,267	6,135
3	14,605	14,103	13,648	13,233	12,851	12,500	12,174	11,871	11,589	11,326	11,078	10,846
4	29,789	28,766	27,838	26,991	26,213	25,495	24,831	24,214	23,639	23,100	22,596	22,121
5	53,892	52,043	50,363	48,830	47,422	46,124	44,923	43,806	42,765	41,792	40,879	40,021
6	87,263	84,269	81,550	79,067	76,787	74,686	72,740	70,932	69,247	67,671	66,193	64,803

TABLE NO. 22-H—FOR PROPANE GAS PRESSURE OF 10.0 psi WITH MAXIMUM PRESSURE DROP OF 3.0 psi
Maximum Delivery Capacity in Cubic Feet of Gas per Hour of I.P.S. Pipe of Different Diameters and Lengths Carrying Propane Gas of 1.52 Specific Gravity

PIPE SIZE	Length of Pipe (In Feet)											
(In Inches)	50′	100′	150′	200′	250′	300′	350′	400′	450′	500′	550′	600′
½	1,000	690	550	470	420	380	350	325	300	285	272	260
¾	2,070	1,423	1,142	978	867	785	722	672	631	596	566	540
1	3,899	2,680	2,152	1,842	1,632	1,479	1,361	1,266	1,188	1,122	1,066	1,017
1¼	8,005	5,502	4,418	3,782	3,351	3,037	2,794	2,599	2,439	2,303	2,188	2,087
1½	11,994	8,244	6,620	5,666	5,022	4,550	4,186	3,894	3,654	3,451	3,278	3,127
2	23,100	15,877	12,750	10,912	9,671	8,763	8,062	7,500	7,037	6,647	6,313	6,023
2½	36,818	25,305	20,321	17,392	15,414	13,966	12,849	11,953	11,215	10,594	10,062	9,599
3	65,088	44,734	35,923	30,746	27,249	24,690	22,714	21,131	19,827	18,728	17,787	16,969
	650′	700′	750′	800′	850′	900′	950′	1000′	1100′	1200′	1300′	1400′
½	250	240	230	222	215	208	202	198	188	180	171	164
¾	517	496	478	462	447	433	421	409	389	371	355	341
1	973	935	901	870	842	816	793	771	732	699	669	643
1¼	1,999	1,920	1,850	1,786	1,729	1,676	1,628	1,583	1,504	1,434	1,374	1,320
1½	2,995	2,877	2,772	2,676	2,590	2,511	2,439	2,372	2,253	2,149	2,058	1,977
2	5,767	5,541	5,338	5,155	4,988	4,836	4,697	4,568	4,339	4,139	3,964	3,808
2½	9,192	8,831	8,507	8,215	7,950	7,708	7,486	7,281	6,915	6,597	6,318	6,069
3	16,250	15,611	15,040	14,523	14,055	13,627	13,234	12,872	12,225	11,663	11,169	10,730
4	33,145	31,842	30,676	29,623	28,667	27,795	26,993	26,255	24,935	23,789	22,780	21,885
	1500′	1600′	1700′	1800′	1900′	2000′	2100′	2200′	2300′	2400′	2500′	2600′
½	158	152	148	143	139	136	133	130	127	124	121	118
¾	329	317	307	298	289	281	274	267	261	255	249	244
1	619	598	579	561	545	530	516	503	491	480	470	460
1¼	1,271	1,228	1,138	1,152	1,119	1,088	1,060	1,033	1,009	986	964	944
1½	1,905	1,839	1,780	1,726	1,676	1,630	1,588	1,548	1,512	1,477	1,445	1,415
2	3,669	3,543	3,428	3,324	3,228	3,140	3,058	2,982	2,911	2,845	2,783	2,724
2½	5,847	5,646	5,464	5,298	5,145	5,004	4,874	4,753	4,640	4,534	4,435	4,342
3	10,337	9,982	9,660	9,366	9,096	8,847	8,616	8,402	8,203	8,016	7,841	7,676
4	21,083	20,360	19,705	19,103	18,552	18,045	17,575	17,138	16,731	16,350	15,993	15,657
5	38,143	36,834	35,645	34,560	33,564	32,645	31,795	31,005	30,268	29,579	28,933	28,325
6	61,762	59,643	57,718	55,961	54,348	52,860	51,483	50,204	49,011	47,895	46,849	45,865

TABLE NO. 22-I—MINIMUM DEMAND FACTORS FOR CALCULATING GAS PIPING SYSTEMS IN MOBILE HOME PARKS

NUMBER OF MOBILE HOME SITES	DEMAND FACTOR Btu/h MOBILE HOME SITE
1	125,000
2	117,000
3	104,000
4	96,000
5	92,000
6	87,000
7	83,000
8	81,000
9	79,000
10	77,000
11-20	66,000
21-30	62,000
31-40	58,000
41-60	55,000
Over 60	50,000

Chapter 23
HYDRONIC PANEL HEATING SYSTEMS

General

Sec. 2301. The purpose of this chapter is to establish and provide minimum standards for the protection of public health, welfare and property by regulating and controlling the design and installation of panel heating systems.

Installation

Sec. 2302. (a) Panel systems shall be designed and installed in accordance with installation standards incorporated in Appendix C, Panel Heating, and the requirements of this code.

(b) Piping to be embedded in concrete shall be pressure tested prior to pouring concrete. During pouring, the pipe shall be maintained at the proposed operating pressure.

Piping Materials

Sec. 2303. (a) **Panel.** Piping for heating panel shall be standard-weight steel pipe, Type L copper tubing, polybutylene or other approved plastic pipe or tubing rated at 100 psi at 180°F. in accordance with design stresses listed in Appendix C, or other materials suitable for this type of design approved by the building official.

(b) **Hot-water Supply Lines.** Piping for hot-water supply lines shall be installed according to requirements in Chapter 21.

Piping Joints

Sec. 2304. Joints of pipe or tubing forming the panel that are embedded in a portion of the building, for example, concrete or plaster, shall be in accordance with the following:

1. Steel pipe welded with electrical arc or oxygen/acetylene method.
2. Copper tubing joined with solder or copper brazing rods having a melting point of 1000°F.
3. Polybutylene pipe and tubing installed in continuous lengths or with heat-fused polybutylene fittings.

Joints of other piping in cavities or running exposed shall be joined by the use of normally accepted methods in accordance with manufacturer's recommendations and related sections of this code.

Heat Sources

Sec. 2305. Heat sources for generating hot water for use in hydronic panel radiant heating systems shall include conventional fossil fuel, hot water boilers, electrical resistance heated boilers, air/water or water/water heat pumps or solar heat collector systems. The latter system may include booster or back-up heating units.

Systems shall be protected by pressure-temperature relief valves as outlined in this code.

Testing

Sec. 2306. Approved piping or tubing installed as a portion of a radiant panel system that will be embedded in the walls, floors or ceilings of the building it is designed to heat shall be tested for leaks by the hydrostatic test method by applying at least 100 psi water pressure or one and one-half times the operating pressure, whichever is the greater.

For metal piping, a pressure gage shall be connected to the piping, and after the pressure has been raised, the hydrostatic pressure connection shall be discontinued, and the systems under pressure shall remain at the test pressure for a sufficient period of time to determine whether any leaks exist in the system. Leaks shall be indicated by the pressure drop on the gage. Minimum test period shall be 30 minutes.

For flexible plastic piping, the test pressure shall be applied for a period of 30 minutes. During this time, the system shall be maintained at the test pressure by the periodic addition of makeup water to compensate for the initial stretching of the pipe. The system shall then be visually inspected for tightness.

Tests for tightness of radiant piping systems shall be witnessed by the building official.

Chapter 24

PROCESS PIPING

General

Sec. 2401. The regulations of this chapter shall govern the installation of process piping in or in conjunction with a building or structure or located upon the premises.

Definitions

Sec. 2402. For the purposes of this chapter, certain terms, phrases, words, and their derivatives shall be interpreted as set forth in this section.

APPROVED. See Section 403.

EMERGENCY ALARM SYSTEM is a system intended to provide the indication and warning of abnormal conditions and summon appropriate aid.

EMERGENCY CONTROL STATION is an approved location on the premises where signals from emergency equipment are received.

FABRICATION AREA (FAB AREA) is an area within a Group H, Division 6 or 7 Occupancy in which there are processes involving hazardous production materials and may include ancillary rooms or areas such as dressing rooms and offices that are directly related to the fab area processes.

HAZARDOUS PROCESS PIPING (HPP) is a process material piping or tubing conveying a liquid or gas that has a degree-of-hazard rating in health, flammability or reactivity of Class 3 or 4 as ranked by U.F.C. Standard No. 79-3.

HPM STORAGE ROOM is a room used for the storage or dispensing of hazardous production material (HPM) and which is classified as a Group H, Division 1 or Division 2 Occupancy.

NONHAZARDOUS PROCESS PIPING (NPP) is production material piping or tubing conveying the liquid or gas which is not classified as hazardous production material piping.

PROCESS PIPING is piping or tubing which conveys liquid or gas and which is used directly in research, laboratory or production processes and which is not regulated under the mechanical or plumbing code.

SERVICE CORRIDOR is a fully enclosed passage used for transporting hazardous production materials and purposes other than required exiting.

USE (MATERIAL) is the placing in action or making available for service by opening or connecting any container utilized for confinement of material whether a solid, liquid or gas.

Permit

Sec. 2403. It shall be unlawful to install, alter or repair or cause to be installed, altered or repaired any process material piping without first obtaining a permit.

Permits for process piping shall show the total number of outlets to be provided for on each system and such other information as may be required by the building official.

Fees for process piping permits are included in Table No. 3-A.

Plans Required

Sec. 2404. Plans, engineering calculations, diagrams and other data shall be submitted in one or more sets with each application for a permit. The building official may require plans, computations and specifications to be prepared and designed by an engineer licensed by the state to practice as such.

When plans or other data are submitted for review, a plan review fee shall be paid as provided in Section 304 (c).

Workmanship

Sec. 2405. Process piping shall not be strained or bent nor shall tanks, vessels, vats, appliances or cabinets be supported by or develop strain or stress on the piping.

Inspections

Sec. 2406. (a) **General.** Upon completion of the installation, alteration or repair of process piping, and prior to the use thereof, the building official shall be notified that such piping is ready for inspection.

Excavations required for the installation of underground piping shall be kept open until such time as the piping has been inspected and approved. If any such piping is covered or concealed before such approval, it shall be exposed upon the direction of the building official.

(b) **Required Inspections.** The building official shall make the following inspections and shall either approve that portion of the work as completed, or shall notify the permit holder wherein the same fails to comply with this code.

1. **Rough piping inspection.** This inspection shall be made after all process piping authorized by the permit has been installed, and before any such piping has been covered or concealed. This inspection shall include a determination that the piping size, material and installation meet the requirements of this code.

2. **Final piping inspection.** This inspection shall be made after all piping authorized by the permit has been installed and after all portions thereof which are to be covered or concealed are so concealed. This inspection shall include a pressure test, at which time the piping shall stand a pressure of not less than two and one-half times the maximum designed operating pressure but in no case less than 100 psig. Test pressures shall be held for a length of time satisfactory to the building official, but in no case for less than 30 minutes with no perceptible drop in pressure. HPM drain, waste, and vent piping shall be tested in accordance with the Plumbing Code. Tests shall be made in the presence of the building official. Necessary apparatus for conducting tests shall be furnished by the permit holder.

(c) **Other Inspections.** In addition to the inspections required by this section, the building official may require a special inspector, as specified in Section 306 of the Building Code, during installation of piping systems. In cases where the work authorized was installed in accordance with plans and specifications prepared by an engineer, the building official may require a final signed report stating that the work was installed in accordance with the approved plans and specifications and the applicable provisions of this chapter.

Piping and Tubing

Sec. 2407. (a) **General.** Process piping and tubing shall comply with this subsection and shall be installed in accordance with nationally recognized standards. Piping and tubing systems shall be metallic unless the material being transported is incompatible with such system.

(b) **Hazardous Process Piping (HPP).** 1. **General.** HPP supply piping or tubing in service corridors shall be exposed to view. HPP piping shall be identified in accordance with nationally recognized standards to indicate the material being transported. All liquid HPP piping shall have an approved means for directing any spilled materials to an approved containment or drainage system.

All liquid HPP waste or drainage system shall be installed in accordance with the plumbing code.

2. **Installation in exit corridors and above other occupancies.** Hazardous process shall not be located within exit corridors or above areas not classified as Group H, Division 6 or 7 Occupancies except as permitted by this subsection.

Hazardous production material piping and tubing may be installed within the space defined by the walls of exit corridors and the floor or roof above or in concealed spaces above other occupancies under the following conditions:

A. Automatic sprinklers shall be installed within the space unless the space is less than 6 inches in least dimension.

B. Ventilation at not less than six air changes per hour shall be provided. The space shall not be used to convey air from any other area.

C. When the piping or tubing is used to transport HPP liquids, a receptor shall be installed below such piping or tubing. The receptor shall be designed to collect any discharge or leakage and drain it to an approved location. The one-hour enclosure shall not be used as part of the receptor.

D. All HPP supply piping and tubing and HPP nonmetallic waste lines shall be separated from the exit corridor and from any occupancy other than Group H, Division 6 by construction as required for walls or partitions that have a fire-protection rating of not less than one-hour. When gypsum wallboard is used, joints on the piping side of the enclosure need not be taped, provided the joints occur over framing members. Access openings into the enclosure shall be protected by approved fire assemblies.

E. Readily accessible manual or automatic remotely activated fail-safe emergency shutoff valves shall be installed on piping and tubing other than waste lines at the following locations:

   (i) At branch connections into the fabrication area.

   (ii) At entries into exit corridors.

   Excess flow valves shall be installed as required by the Fire Code.

F. Electrical wiring and equipment located in the piping space shall be approved for Class I, Division 2, Hazardous Locations.

EXCEPTION: Occasional transverse crossing of the corridors by supply piping which is enclosed within a ferrous pipe or tube for the width of the corridor need not comply with Items A through F.

(c) **Special Requirements for HPP Gases.** 1. **General.** In addition to other requirements of this section, HPP gases shall comply with this subsection and the Fire Code.

2. **Special Provisions.** A. **Excess flow control.** Where HPP supply gas is carried in pressurized piping, a fail-safe system shall shut off flow due to a rupture in the piping. Where the piping originates from outside the building, the valve shall be located outside the building as close to the bulk source as practical.

B. **Piping and tubing installation.** Piping and tubing shall be installed in accordance with approved standards. Supply piping for hazardous production materials having a health hazard ranking of 3 or 4 shall have welded connections throughout unless an exhausted enclosure is provided.

EXCEPTION: Material which is incompatible with ferrous piping may be installed in nonmetallic piping with approved connections.

C. **Gas-detection system.** When hazardous production material gas is used or dispensed and the physiological warning properties for the gas are at a higher level than the accepted permissible exposure limit for the gas, a continuous gas-monitoring system shall be provided to detect the presence of a short-term hazard condition. When dispensing occurs and flammable gases or vapors may be present in quantities in excess of 20 percent of the lower explosive limit, a continuous gas-monitoring system shall be provided. The monitoring system shall be connected to the emergency control station.

APPENDIX C

Chapter 9

Sizing of Venting Systems Serving Appliances Equipped with Draft Hoods and Appliances Listed for Use with Type B Vents

See Sections 103 and 901, Uniform Mechanical Code.

Use of Tables

Sec. 918. (a) **General.** Gas-venting systems serving appliances equipped with draft hoods and appliances listed for use with Type B vents may be sized in accordance with tables in this chapter, when such design method has been approved by the building official.

(b) **Symbols.** Symbols used in Tables Nos. C-9-A, C-9-B and C-9-C are as indicated in Figures Nos. 1 and 2. Symbols used in Tables Nos. C-9-D, C-9-E and C-9-F are as indicated in Figures Nos. 3 and 4.

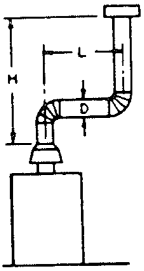

FIGURE NO. 1

Double-wall or asbestos cement Type B vent serving a single appliance. (See Tables Nos. C-9-A and C-9-B.)

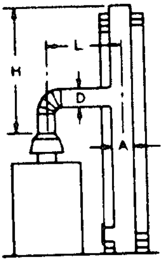

FIGURE NO. 2

Masonry chimney serving a single appliance. (See Table No. C-9-C.)

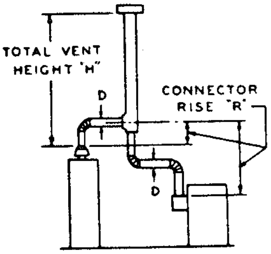

FIGURE NO. 3

Double-wall or asbestos cement Type B vents serving two or more appliances. (See Tables Nos. C-9-D and C-9-E.)

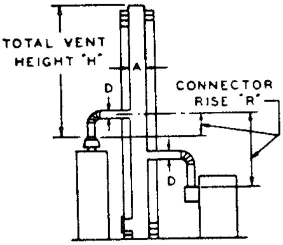

FIGURE NO. 4

Masonry chimney serving two or more appliances. (See Table No. C-9-F.)

(c) **Notes For Tables Nos. C-9-A, C-9-B and C-9-C.** Notes for appliance vents covered in Tables Nos. C-9-A, C-9-B and C-9-C are as indicated below:

1. When the specified diameter of the draft hood supplied by the manufacturer or the diameter of the appliance vent collar is larger than the vent size determined from Tables Nos. C-9-A, C-9-B or C-9-C, a one-size-smaller vent may be used, provided the height "H" is at least 10 feet (10 inches to 8 inches is a one-size reduction).

   EXCEPTION: Irrespective of the required vent size obtained from the tables, 4-inch draft hoods shall not be connected to 3-inch vents.

2. Only vertical vent connectors rising from top-outlet draft hoods may employ zero lateral capacities.

3. High-altitude installations shall be sized based on sea level input ratings.

(d) **Notes for Tables Nos. C-9-D, C-9-E and C-9-F.** Notes for multiple appliance vents covered in Tables Nos. C-9-D, C-9-E and C-9-F are as indicated below:

1. The connector length shall not exceed 1½ feet for every inch of connector diameter.

2. The connector capacity shall be reduced 10 percent for each 90-degree turn in excess of two.

3. The common vent capacity shall be reduced by 10 percent for each 90-degree turn in excess of two.

4. Connectors shall be equal to or larger than draft hood outlets.

5. If both connectors are the same size, the common vent shall be at least one size larger, regardless of tabulated capacity.

6. The common vent shall be equal to or larger than the largest connector.

7. Interconnection fittings shall be the same size as the common vent.

8. High-altitude installations shall be sized based on sea level input rating.

TABLE NO. C-9-A—CAPACITY OF DOUBLE-WALL OR ASBESTOS CEMENT TYPE B VENTS WITH SINGLE-WALL CONNECTORS SERVING A SINGLE APPLIANCE

Total Vent Height H (feet)	Lateral L (feet)	Vent Diameter – D (Inches)							
		3	4	5	6	7	8	10	12
		Maximum Appliance Input Rating in Thousands of Btu/h							
6	0	39	70	116	170	232	312	500	750
	2	31	55	94	141	194	260	415	620
	5	28	51	88	128	177	242	390	600
8	0	42	76	126	185	252	340	542	815
	2	32	61	102	154	210	284	451	680
	5	29	56	95	141	194	264	430	648
	10		49	86	131	180	250	406	625
10	0	45	84	138	202	279	372	606	912
	2	35	67	111	168	233	311	505	760
	5	32	61	104	153	215	289	480	724
	10		54	94	143	200	274	455	700
	15			84	130	186	258	432	666
15	0	49	91	151	223	312	420	684	1040
	2	39	72	122	186	260	350	570	865
	5		67	110	170	240	325	540	825
	10			103	158	223	308	514	795
	15				144	207	291	488	760
	20					195	273	466	726
20	0		101	163	252	342	470	770	1190
	2		80	136	210	286	392	641	990
	5			123	192	264	364	610	945
	10				178	246	345	571	910
	15				163	228	326	550	870
	20						306	525	832
30	0			183	276	384	529	878	1370
	2				230	320	441	730	1140
	5				210	296	410	694	1080
	10					274	388	656	1050
	15						366	625	1000
	20						344	596	960
	30							540	890
50	0						590	980	1550
	2						492	820	1290
	5						474	780	1230
	10							730	1190
	15							705	1130
	20								1080
	30								1010

See Figure No. 1 for single-appliance vents.

TABLE NO. C-9-B—CAPACITY OF TYPE B DOUBLE-WALL VENTS WITH TYPE B DOUBLE-WALL CONNECTORS SERVING A SINGLE APPLIANCE

Total Vent		Vent Diameter – (Inches)													
Height H (feet)	Lateral L (feet)	3	4	5	6	7	8	10	12	14	16	18	20	22	24
		Maximum Appliance Input Rating in Thousands of Btu/h													
6	0	46	86	141	205	285	370	570	850	1170	1530	1960	2430	2950	3520
	2	36	67	105	157	217	285	455	650	890	1170	1480	1850	2220	2670
	6	32	61	100	149	205	273	435	630	870	1150	1470	1820	2210	2650
	12	28	55	91	137	190	255	406	610	840	1110	1430	1795	2180	2600
8	0	50	94	155	235	320	415	660	970	1320	1740	2220	2750	3360	4010
	2	40	75	120	180	247	322	515	745	1020	1340	1700	2110	2560	3050
	8	35	66	109	165	227	303	490	720	1000	1320	1670	2070	2530	3030
	16	28	58	96	148	206	281	458	685	950	1260	1600	2035	2470	2960
10	0	53	100	166	255	345	450	720	1060	1450	1925	2450	3050	3710	4450
	2	42	81	129	195	273	355	560	850	1130	1480	1890	2340	2840	3390
	10	36	70	115	175	245	330	525	795	1080	1430	1840	2280	2780	3340
	20		60	100	154	217	300	486	735	1030	1360	1780	2230	2720	3250
15	0	58	112	187	285	390	525	840	1240	1720	2270	2900	3620	4410	5300
	2	48	93	150	225	316	414	675	985	1350	1770	2260	2800	3410	4080
	15	37	76	128	198	275	373	610	905	1250	1675	2150	2700	3300	3980
	30		60	107	169	243	328	553	845	1180	1550	2050	2620	3210	3840
20	0	61	119	202	307	430	575	930	1350	1900	2520	3250	4060	4980	6000
	2	51	100	166	249	346	470	755	1100	1520	2000	2570	3200	3910	4700
	10	44	89	150	228	321	443	710	1045	1460	1940	2500	3130	3830	4600
	20	35	78	134	206	295	410	665	990	1390	1880	2430	3050	3760	4550
	30		68	120	186	273	380	626	945	1270	1700	2330	2980	3650	4390

30	0	64	128	220	336	475	650	1060	1550	2170	2920	3770	4750	5850	7060
	2	56	112	185	280	394	535	865	1310	1800	2380	3050	3810	4650	5600
	20		90	154	237	343	473	784	1185	1650	2200	2870	3650	4480	5310
	40				200	298	415	705	1075	1520	2060	2700	3480	4270	5140
40	0	66	132	228	353	500	685	1140	1730	2400	3230	4180	5270	6500	7860
	2	59	118	198	298	420	579	960	1420	2000	2660	3420	4300	5260	6320
	20		96	167	261	377	516	860	1310	1830	2460	3200	4050	5000	6070
	40				223	333	460	785	1205	1710	2310	3020	3840	4780	5820
60	0		136	236	373	535	730	1250	1920	2700	3650	4740	6000	7380	9000
	2		125	213	330	470	650	1060	1605	2250	3020	3920	4960	6130	7400
	30			170	275	397	555	930	1440	2050	2780	3640	4700	5730	7000
	60					334	475	830	1285	1870	2560	3380	4330	5420	6600
80	0			239	384	550	755	1290	2020	2880	3900	5100	6450	8000	9750
	2			217	350	495	683	1145	1740	2460	3320	4310	5450	6740	8200
	40				275	404	570	980	1515	2180	2980	3920	5000	6270	7650
	80							850	1420	2000	2750	3640	4680	5850	7200
100	0				400	560	770	1310	2050	2950	4050	5300	6700	8600	10300
	2				375	510	700	1170	1820	2550	3500	4600	5800	7200	8800
	50					405	575	1000	1550	2250	3100	4050	5300	6600	8100
	100							870	1430	2050	2850	3750	4900	6100	7500

TABLE NO. C-9-C—CAPACITY OF MASONRY CHIMNEYS AND SINGLE-WALL VENT CONNECTORS SERVING A SINGLE APPLIANCE

Total Vent Height H (feet)	Lateral L (feet)	Single-Wall Vent Connector Diameter – D (Inches)							
		To be used with chimney areas not less than those at bottom							
		3	4	5	6	7	8	10	12
		Maximum Appliance Input Rating in Thousands of Btu/h							
6	2	28	52	86	130	180	247	400	580
	5		48	81	118	164	230	375	560
8	2	29	55	93	145	197	265	445	650
	5		51	87	133	182	246	422	638
	10			79	123	169	233	400	598
10	2	31	61	102	161	220	297	490	722
	5		56	95	147	203	276	465	710
	10			86	137	189	261	441	665
	15				125	175	246	421	634
15	2		67	113	178	249	335	560	840
	5		61	106	163	230	312	531	825
	10			96	151	214	294	504	774
	15				138	198	278	481	738
	20					184	261	459	706
20	2		73	123	200	273	374	625	950
	5			115	183	252	348	594	930
	10				170	235	330	562	875
	15				156	217	311	536	835
	20					202	292	510	800
30	2			136	215	302	420	715	1110
	5				196	279	391	680	1090
	10					260	370	644	1020
	15						349	615	975
	20						327	585	932
	30							544	865
50	2							810	1240
	5							770	1220
	10							728	1140
	15							695	1090
	20								1040
	30								970
Minimum Internal Area of Chimney-A Square Inches		19		28	38	50	63	95	132

See Table No. C-9-G for masonry chimney liner sizes.

See Figure No. 2 for single-appliance vents.

TABLE NO. C-9-D—CAPACITY OF TYPE B DOUBLE-WALL VENTS WITH TYPE B DOUBLE-WALL CONNECTORS SERVING TWO OR MORE APPLIANCES

Vent Connector Capacity															
Total Vent Height H (feet)	Connector Rise R (feet)	Vent Connector Diameter — D (inches)													
		3	4	5	6	7	8	10	12	14	16	18	20	22	24
		Maximum Appliance Input Rating in Thousands of Btu/h													
6	1	26	46	72	104	142	185	289	416	577	755	955	1180	1425	1700
	2	31	55	86	124	168	220	345	496	653	853	1080	1335	1610	1920
	3	35	62	96	139	189	248	386	556	740	967	1225	1510	1830	2180
8	1	27	48	76	109	148	194	303	439	601	805	1015	1255	1520	1810
	2	32	57	90	129	175	230	358	516	696	910	1150	1420	1720	2050
	3	36	64	101	145	198	258	402	580	790	1030	1305	1610	1950	2320
10	1	28	50	78	113	154	200	314	452	642	840	1060	1310	1585	1890
	2	33	59	93	134	182	238	372	536	730	955	1205	1490	1800	2150
	3	37	67	104	150	205	268	417	600	827	1080	1370	1690	2040	2430
15	1	30	53	83	120	163	214	333	480	697	910	1150	1420	1720	2050
	2	35	63	99	142	193	253	394	568	790	1030	1305	1610	1950	2320
	3	40	71	111	160	218	286	444	640	898	1175	1485	1835	2220	2640
20	1	31	56	87	125	171	224	347	500	740	965	1225	1510	1830	2190
	2	37	66	104	149	202	265	414	596	840	1095	1385	1710	2070	2470
	3	42	74	116	168	228	300	466	672	952	1245	1575	1945	2350	2800
30	1	33	59	93	134	182	238	372	536	805	1050	1330	1645	1990	2370
	2	39	70	110	158	215	282	439	632	910	1190	1500	1855	2240	2670
	3	44	79	124	178	242	317	494	712	1035	1350	1710	2110	2550	3040
40	1	35	62	97	140	190	248	389	560	850	1110	1405	1735	2100	2500
	2	41	73	115	166	225	295	461	665	964	1260	1590	1965	2380	2830
	3	46	83	129	187	253	331	520	748	1100	1435	1820	2240	2710	3230
60 to 100	1	37	66	104	150	204	266	417	600	926	1210	1530	1890	2280	2720
	2	44	79	123	178	242	316	494	712	1050	1370	1740	2150	2590	3090
	3	50	89	138	200	272	355	555	800	1198	1565	1980	2450	2960	3520

(Continued)

TABLE NO. C-9-D—CAPACITY OF TYPE B DOUBLE-WALL VENTS WITH TYPE B DOUBLE-WALL CONNECTORS SERVING TWO OR MORE APPLIANCES—(Continued)

Total Vent Height H (feet)	Common Vent Capacity													
	Common Vent Diameter—D (Inches)													
	3	4	5	6	7	8	10	12	14	16	18	20	22	24
	Combined Appliance Input Rating in Thousands of Btu/h													
6	–	65	103	147	200	260	410	588	815	1065	1345	1660	1970	2390
8	–	73	114	163	223	290	465	652	912	1190	1510	1860	2200	2680
10	–	79	124	178	242	315	495	712	995	1300	1645	2030	2400	2920
15	–	91	144	206	280	365	565	825	1158	1510	1910	2360	2790	3400
20	–	102	160	229	310	405	640	916	1290	1690	2140	2640	3120	3800
30	–	118	185	266	360	470	740	1025	1525	1990	2520	3110	3680	4480
40	–	131	203	295	405	525	820	1180	1715	2240	2830	3500	4150	5050
60	–		224	324	440	575	900	1380	2010	2620	3320	4100	4850	5900
80	–			344	468	610	955	1540	2250	2930	3710	4590	5420	6600
100	–				479	625	975	1670	2450	3200	4050	5000	5920	7200

See Figure No. 3 and notes for multiple-appliance vents.

TABLE NO. C-9-E—CAPACITY OF DOUBLE-WALL AND ASBESTOS-CEMENT TYPE B VENTS WITH SINGLE-WALL CONNECTORS SERVING TWO OR MORE APPLIANCES

Single-wall Vent Connector Capacity

Total Vent Height H (feet)	Connector Rise R (feet)	Vent Connector Diameter—D (Inches)					
		3	4	5	6	7	8
		Maximum Appliance Input Rating in Thousands of Btu/h					
6 to 8	1	21	40	68	102	146	205
	2	28	53	86	124	178	235
	3	34	61	98	147	204	275
15	1	23	44	77	117	179	240
	2	30	56	92	134	194	265
	3	35	64	102	155	216	298
30 and up	1	25	49	84	129	190	270
	2	31	58	97	145	211	295
	3	36	68	107	164	232	321

Common Vent Capacity

Total Vent Height H (feet)	Common Vent Diameter (Inches)						
	4	5	6	7	8	10	12
	Combined Appliance Input Rating in Thousands of Btu/h						
6	48	78	111	155	205	320	NR
8	55	89	128	175	234	365	505
10	59	95	136	190	250	395	560
15	71	115	168	228	305	480	690
20	80	129	186	260	340	550	790
30		147	215	300	400	650	940
50				360	490	810	1190

See Figure No. 3 and notes for multiple-appliance vents.

TABLE NO. C-9-F—CAPACITY OF A MASONRY CHIMNEY AND SINGLE-WALL VENT CONNECTORS SERVING TWO OR MORE APPLIANCES

Single-Wall Vent Connector Capacity							
Total Vent Height H (feet)	Rise Connector R (feet)	Vent Connector Diameter—D (Inches)					
		3	4	5	6	7	8
		Maximum Appliance Input Rating in Thousands of Btu/h					
6 to 8	1	21	39	66	100	140	200
	2	28	52	84	123	172	231
	3	34	61	97	142	202	269
15	1	23	43	73	112	171	225
	2	30	54	88	132	189	256
	3	34	63	101	151	213	289
30 and up	1	24	47	80	124	183	250
	2	31	57	93	142	205	282
	3	35	65	105	160	229	312

Common Chimney Capacity						
Total Vent Height H (feet)	Minimum Internal Area of Chimney—A (Square Inches)					
	19	28	38	50	78	113
	Combined Appliance Input Rating in Thousands of Btu/h					
6	45	71	102	142	245	
8	52	81	118	162	277	405
10	56	89	129	175	300	450
15	66	105	150	210	360	540
20	74	120	170	240	415	640
30		135	195	275	490	740
50				325	600	910

See Table No. C-9-G for masonry chimney liner sizes.

See Figure No. 4 and notes for multiple-appliance vents.

TABLE NO. C-9-G—MASONRY CHIMNEY LINER DIMENSIONS WITH CIRCULAR EQUIVALENTS[1]

Nominal Liner Size (Inches)	Inside Dimensions of Liner in (Inches)	Inside Diameter or Equivalent Diameter (Inches)	Equivalent Area (Square Inches)
4 x 8	2½ x 6½	4	12.2
		5	19.6
		6	28.3
		7	38.3
8 x 8	6¾ x 6¾	7.4	42.7
		8	50.3
8 x 12	6½ x 10½	9	63.6
		10	78.5
12 x 12	9¾ x 9¾	10.4	83.3
		11	95
12 x 16	9½ x 13½	11.8	107.5
		12	113.0
		14	153.9
16 x 16	13¼ x 13¼	14.5	162.9
		15	176.7
16 x 20	13 x 17	16.2	206.1
		18	254.4
20 x 20	16¾ x 16¾	18.2	260.2
		20	314.1
20 x 24	16½ x 20½	20.1	314.2
		22	380.1
24 x 24	20¼ x 20¼	22.1	380.1
		24	452.3
24 x 28	20¼ x 24¼	24.1	456.2
28 x 28	24¼ x 24¼	26.4	543.3
		27	572.5
30 x 30	25½ x 25½	27.9	607
		30	706.8
30 x 36	25½ x 31½	30.9	749.9
		33	855.3
36 x 36	31½ x 31½	34.4	929.4
		36	1017.9

[1] When liner sizes differ dimensionally from those shown, equivalent diameters may be used.

REFERENCE STANDARDS

The following standards* are intended for use as a guide in the design, testing and installation of equipment regulated by this code.

A

AIR-CONDITIONING APPLIANCES, GAS-FIRED ABSORPTION SUMMER, ANSI Z21.40.1-1981
  Addenda Z21.40.1a-1982

AIR FILTER UNITS, TEST PERFORMANCE OF, UL 900, 1977, with 1983 revision

AUTOMATIC GAS IGNITION SYSTEMS AND COMPONENTS, ANSI Z21.20-1979
  Addenda Z21.20a-1979
  Addenda Z21.20b-1982

AUTOMATIC INTERMITTENT PILOT IGNITION SYSTEMS FOR FIELD INSTALLATION, ANSI Z21.71-1981

B

BOILERS, GAS UTILIZATION EQUIPMENT IN LARGE, ANSI Z83.3-1971
  Addenda Z83.3a-1972
  Addenda Z83.3b-1976

BOILERS, GAS-FIRED LOW-PRESSURE STEAM AND HOT-WATER HEATING, ANSI Z21.13-1982
  Addenda Z21.13a

BOILERS, GAS-FIRED HIGH-PRESSURE STEAM AND HOT-WATER, ANSI Z21.59-1974

BOILERS, LOW-PRESSURE CAST-IRON HEATING, I-B-R Testing and Rating Code, The Institute of Boiler and Radiator Manufacturers, Seventh Edition, January, 1966

BOILERS, STEEL, SBI Testing and Rating Code, the Steel Boiler Institute, Tenth Edition, September, 1965

C

CENTRAL COOLING AIR CONDITIONERS, UL 465, 1982 with 1984 revision

CENTRAL FURNACES, DIRECT VENT, ANSI Z21.64-1978
  Addenda Z21.64a-1980
  Addenda Z21.64b-1982

CENTRAL FURNACES, GAS-FIRED (except DIRECT VENT and SEPARATED COMBUSTION SYSTEM CENTRAL FURNACES), ANSI Z21.47-1983

CENTRAL FURNACES, SEPARATED COMBUSTION SYSTEM, ANSI Z83.10-1982
  Addenda Z83.10a-1983

CHIMNEYS, FACTORY-BUILT, MEDIUM-HEAT APPLIANCE, UL 959, 1976 with 1982 revision

CHIMNEYS, FACTORY-BUILT, RESIDENTIAL TYPE AND BUILDING HEATING APPLIANCE, UL 103, 1983

*Abbreviations referred to in this list are identified as:

ANSI—American National Standard approved by the American National Standards Institute, Inc., 1430 Broadway, New York, New York 10018.

ASHRAE—The American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, NE, Atlanta, GA 30329.

I-B-R—The Institute of Boiler and Radiator Manufacturers, 393 Seventh Avenue, New York, New York 10001.

PPI—Plastics Pipe Institute, 355 Lexington Avenue, New York, New York 10017.

SBI—Steel Boiler Institute, 393 Seventh Avenue, New York, New York 10001.

UL—Underwriters Laboratories Inc., Standards Issued by Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, Illinois 60062.

R—Reaffirmed as up-to-date.

CLOTHES DRYERS, GAS
  Volume I, Type 1—Clothes Dryers, ANSI Z21.5.1-1982
  Volume II, Type 2—Clothes Dryers, ANSI Z21.5.2-1979
    Addenda Z21.5.2a-1981
    Addenda Z21.5.2b-1982

COMMERCIAL ELECTRIC DISHWASHERS, UL 921, 1978 with 1983 revisions

COMMERCIAL GAS BAKING AND ROASTING OVENS, ANSI Z83.12-1980
  Addenda Z83.12a-1983

COMMERCIAL REFRIGERATORS AND FREEZERS, UL 471, 1978 with 1983 revisions

CONNECTORS, METAL, FOR GAS APPLIANCES, ANSI Z21.24-1981

CONNECTORS FOR MOVABLE GAS APPLIANCES, ANSI Z21.69-1979
  Addenda Z21.69a-1983

CONVERSION BURNERS, DOMESTIC GAS, ANSI Z21.17-1984

CONVERSION BURNERS, DOMESTIC GAS, INSTALLATION OF, ANSI Z21.8-1984

COUNTER APPLIANCES, GAS, ANSI Z83.14-1980
  Addenda Z83.14a-1983

D

DECORATIVE GAS APPLIANCES, VENTED, ANSI Z21.50-1982
  Addenda Z21.50a-1982

DECORATIVE GAS APPLIANCES FOR INSTALLATION IN VENTED FIREPLACE, ANSI Z21.60-1981
  Addenda Z21.60a-1982
  Addenda Z21.60b-1984

DEEP FAT FRYERS, HOTEL AND RESTAURANT, GAS, ANSI Z83.13-1980
  Addenda Z83.13a-1983

DIRECT GAS-FIRED INDUSTRIAL AIR HEATERS, ANSI Z83.18-1987

DIRECT GAS-FIRED MAKEUP AIR HEATERS, ANSI Z83.4-1985
  Addenda Z83.4a-1986
  Addenda Z83.4b-1988

DRAFT EQUIPMENT, UL 378, 1973

DRAFT HOODS, ANSI Z21.12-1981
Addenda Z21.12a-1983

DUCT FURNACES, GAS-FIRED, ANSI Z83.9-1982
Addenda Z83.9a-1983

E

EARTHQUAKE ACTUATED AUTOMATIC GAS SHUTOFF SYSTEMS, ANSI Z21.70-1981

ELECTRIC CENTRAL AIR-HEATING EQUIPMENT, UL 1096, 1981 with 1983 revision

ELECTRIC COIN-OPERATED CLOTHES DRYING EQUIPMENT, UL 1556, 1982

ELECTRIC COMMERCIAL CLOTHES-DRYING EQUIPMENT, UL 1240, 1979

ELECTRIC COMMERCIAL CLOTHES-WASHING EQUIPMENT, UL 1206, 1979

F

FAN COIL UNITS AND ROOM FAN HEATER UNITS, UL 883, 1980 with 1983 revisions

FILTERS, GAS, ON APPLIANCES, ANSI Z21.35-1977

FIREPLACE ACCESSORIES, proposed standard, UL 907, 1982

FIREPLACE STOVES, UL 737, 1982

FIREPLACES, FACTORY-BUILT, UL 127, 1981 with 1983 revisions

FLAME ARRESTORS FOR USE ON VENTS OF STORAGE TANKS FOR PETROLEUM OIL AND GASOLINE, ANSI/UL 525, 1979 with 1982 revision

FLEXIBLE CONNECTORS OF OTHER THAN ALL-METAL CONSTRUCTION FOR GAS APPLIANCES, ANSI Z21.45-1979
Addenda Z21.45a-1983

FLOOR FURNACE, GAS-FIRED GRAVITY AND FAN TYPE, ANSI Z21.48-1982
Addenda Z21.48a-1982

FURNACES, SOLID-FUEL AND COMBINATION-FUEL CENTRAL AND SUPPLEMENTARY, UL 391, 1981 with 1983 revision

G

GAS-FIRED HEATING EQUIPMENT, COMMERCIAL INDUSTRIAL (Inputs over 400,000 Btu per hour), UL 795, 1973 with 1982 revision

GAS HOSE CONNECTORS FOR PORTABLE OUTDOOR GAS-FIRED APPLIANCES, ANSI Z21.54-1979
Addenda Z21.54a-1983

GAS HOSE FOR PORTABLE INDOOR GAS-FIRED APPLIANCES, ANSI Z21.2-1983

GAGES AND INDICATORS, LIQUID LEVEL, FOR PETROLEUM PRODUCTS, UL 180, 1980

GAGES AND INDICATORS, LIQUID LEVEL, FOR ANHYDROUS AMMONIA AND LP GAS, UL 565-1973

GAGES INDICATING PRESSURE FOR COMPRESSED GAS SERVICE, UL 404, 1979

GAS-FIRED CONSTRUCTION HEATERS, ANSI Z83.7-1974
  Addenda Z83.7a-1981
  Addenda Z83.7b-1984

GREASE EXTRACTORS FOR EXHAUST DUCTS, UL 710, 1981 with 1983 revision

GREASE FILTERS FOR EXHAUST DUCTS, UL 1046, 1979

H

HEAT PUMPS, UL 559, 1975 with 1984 revisions

HEATING, WATER SUPPLY, AND POWER BOILERS, ELECTRIC, UL 834, 1980 with 1983 revisions

HERMETIC REFRIGERANT MOTOR COMPRESSORS, UL 984, 1984

HOSE, FLEXIBLE METALLIC, UL 536, 1976 with 1984 revision

HOSE, LP GAS, UL 21, 1980 with 1984 revision

HOT PLATES AND LAUNDRY STOVES, DOMESTIC, GAS, ANSI Z21.9-1979
  Addenda Z21.9a-1979
  Addenda Z21.9b-1981

HOUSEHOLD COOKING GAS APPLIANCES, ANSI Z21.1-1982
  Addenda Z21.1a-1982

I

ILLUMINATING APPLIANCES, GAS-FIRED, ANSI Z21.42-1971
  Addenda Z21.42a-1973
  Addenda Z21.42b-1981

INCINERATORS, RESIDENTIAL, UL 791, 1973 with 1981 revision

INFRARED HEATERS, GAS-FIRED, ANSI Z83.6-1982
  Addenda Z83.6a-1984

K

KETTLES, STEAM COOKERS AND STEAM GENERATORS, GAS-FIRED, ANSI Z83.15-1980
  Addenda Z83.15a-1983

M

MECHANICAL REFRIGERATION, SAFETY CODE FOR, ANSI/ASHRAE 15-1978

O

OIL BURNERS, SAFETY STANDARD FOR, ANSI/UL 296, 1980 with 1983 revisions

OIL-BURNING STOVES, UL 896, 1973 with 1974 revisions

OIL-FIRED AIR HEATERS AND DIRECT-FIRED HEATERS, UL 733, 1975 with 1983 revisions

OIL-FIRED BOILER ASSEMBLIES, ANSI/UL 726, 1975 with 1982 revisions

OIL-FIRED CENTRAL FURNACES, ANSI/UL 727, 1980 with 1983 revisions

OIL-FIRED FLOOR FURNACES, ANSI/UL 729, 1976 with 1980 revisions

OIL-FIRED WALL FURNACES, ANSI/UL 730, 1974 with 1980 revisions

OIL-FIRED UNIT HEATERS, ANSI/UL 731, 1975 with 1980 revisions

OUTDOOR COOKING GAS APPLIANCES, ANSI Z21.58-1982
Addenda Z21.58a-1982

P

PANEL HEATING, ASHRAE Systems Volume 1980, Chapter 8

PIPE THREADS, ANSI B2.1-1968 and B2.2-1968 Dryseal

PRESSURE-REGULATING VALVES FOR LP GAS, ANSI/UL 144, 1978

PRESSURE REGULATORS, GAS APPLIANCE, ANSI Z21.18-1981
Addenda Z21.18a-1982

PUMPS FOR OIL-BURNING APPLIANCES, UL 343, 1982

PUMPS, POWER OPERATED FOR ANHYDROUS AMMONIA AND LP GAS, UL 51, 1980

Q

QUICK-DISCONNECT DEVICES FOR USE WITH GAS FUEL, ANSI Z21.41-1978
Addenda Z21.41a-1981
Addenda Z21.41b-1983

R

RANGES, HOTEL AND RESTAURANT GAS AND UNIT BROILERS, ANSI Z83.11-1980
Addenda Z83.11a-1983

REFRIGERANT-CONTAINING COMPONENTS AND ACCESSORIES, NONELECTRICAL, UL 207, 1982

REFRIGERATION AND AIR CONDITIONING CONDENSING AND COMPRESSOR UNITS, UL 303, 1980 with 1983 revisions

REFRIGERATION PIPING, including valves, fittings and welding, ANSI B31.5-1974

REFRIGERATORS USING GAS FUEL, ANSI Z21.19-1983

REGULATORS FOR COMPRESSED GAS, UL 252, 1979

ROOM HEATERS, GAS-FIRED
Volume I, Vented Room Heaters, ANSI Z21.11.1-1983
Volume II, Unvented Room Heaters, ANSI Z21.11.2-1983

ROOM HEATER, SOLID-FUEL TYPE, UL 1482, 1983

S

SWIMMING POOL HEATERS, GAS-FIRED, ANSI Z21.56-1983
Addenda Z21.56a-1984

T

TANK, PIPING AND VALVES FOR OIL-BURNING APPLIANCES, CHAPTERS 2 AND 3 OF NFPA 31-1978, Standard for the Installation of Oil-burning Equipment.

THERMOPLASTIC PIPE AND FITTINGS COMPOUNDS, RECOMMENDED HYDROSTATIC STRENGTHS AND DESIGN STRESSES, PPI Technical Report TR-4, August, 1978

THERMOSTATS, GAS APPLIANCE, ANSI Z21.23-1980

TOILETS, GAS-FIRED, ANSI Z21.61-1983

U

UNIT COOLERS, REFRIGERATION, UL 412, 1980 with 1982 revisions

UNIT HEATERS, GAS, ANSI Z83.8-1981
Addenda Z83.8a-1982
Addenda Z83.8b-1983

V

VALVES, AUTOMATIC FOR GAS APPLIANCES, ANSI Z21.21-1974
Addenda Z21.21a-1977
Addenda Z21.21b-1981

VALVES, CONSTANT-LEVEL OIL, UL 352, 1982

VALVES, ELECTRICALLY OPERATED, UL 429, 1982 with 1983 revision

VALVES FOR ANHYDROUS AMMONIA AND LP GAS, UL 125, 1980

VALVES FOR FLAMMABLE LIQUIDS AND FUEL GASES, UL 842, 1980

VALVES, MANUALLY OPERATED GAS, ANSI Z21.15-1979
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VALVES, RELIEF AND AUTOMATIC GAS SHUTOFF DEVICES FOR HOT WATER SUPPLY SYSTEMS, ANSI Z21.22-1979
Addenda Z21.22a-1983

VALVES, SAFETY RELIEF FOR ANHYDROUS AMMONIA AND LP GAS, UL 132, 1973

VENT DAMPER DEVICES, AUTOMATIC ELECTRICALLY ACTUATED, FOR USE WITH GAS-FIRED APPLIANCES, ANSI Z21.66-1977
Addenda Z21.66a-1981
Addenda Z21.66b-1982

VENT DAMPER DEVICES, AUTOMATIC, MECHANICALLY ACTUATED, FOR USE WITH GAS-FIRED APPLIANCES, ANSI Z21.67-1978
Addenda Z21.67a-1981
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VENT DAMPER DEVICES, AUTOMATIC, THERMALLY ACTUATED, FOR USE WITH GAS-FIRED APPLIANCES, ANSI Z21.68, 1978.
Addenda Z21.68a-1981
Addenda Z21.68b-1982

VENTING SYSTEMS, TYPE L, LOW TEMPERATURE, ANSI, UL 641, 1976

VENT OR CHIMNEY CONNECTOR DAMPERS FOR OIL FIRED APPLIANCES, UL 17, 1982 with 1983 revisions

VENTS, GAS, ANSI, UL 441, 1979 with 1983 revision

W

WALL FURNACES, GAS-FIRED GRAVITY AND FAN-TYPE VENTED, ANSI Z21.49-1982
  Addenda Z21.49a-1982

WALL FURNACES, GAS-FIRED GRAVITY AND FAN-TYPE DIRECT-VENT WALL FURNACES, ANSI Z21.44-1981
  Addenda Z21.44a-1982
  Addenda Z21.44b-1982

WATER HEATERS, GAS
  Volume I, Automatic Storage Type, ANSI Z21.10.1-1984
  Volume III, Circulation Tank, Instantaneous, and Large Automatic Storage Type, ANSI Z21.10.3-1984

APPENDIX D

UNIT CONVERSION TABLES

SI SYMBOLS AND PREFIXES

BASE UNITS		
Quantity	**Unit**	**Symbol**
Length	Meter	m
Mass	Kilogram	kg
Time	Second	s
Electric current	Ampere	A
Thermodynamic temperature	Kelvin	K
Amount of substance	Mole	mol
Luminous intensity	Candela	cd

SI SUPPLEMENTARY UNITS		
Quantity	**Unit**	**Symbol**
Plane angle	Radian	rad
Solid angle	Steradian	sr

SI PREFIXES		
Multiplication Factor	**Prefix**	**Symbol**
1 000 000 000 000 000 000 $= 10^{18}$	exa	E
1 000 000 000 000 000 $= 10^{15}$	peta	P
1 000 000 000 000 $= 10^{12}$	tera	T
1 000 000 000 $= 10^{9}$	giga	G
1 000 000 $= 10^{6}$	mega	M
1 000 $= 10^{3}$	kilo	k
100 $= 10^{2}$	hecto	h
10 $= 10^{1}$	deka	da
0.1 $= 10^{-1}$	deci	d
0.01 $= 10^{-2}$	centi	c
0.001 $= 10^{-3}$	milli	m
0.000 001 $= 10^{-6}$	micro	μ
0.000 000 001 $= 10^{-9}$	nano	n
0.000 000 000 001 $= 10^{-12}$	pico	p
0.000 000 000 000 001 $= 10^{-15}$	femto	f
0.000 000 000 000 000 001 $= 10^{-18}$	atto	a

SI DERIVED UNIT WITH SPECIAL NAMES			
Quantity	**Unit**	**Symbol**	**Formula**
Frequency (of a periodic phenomenon)	hertz	Hz	1/s
Force	newton	N	kg·m/s^2
Pressure, stress	pascal	Pa	N/m^2
Energy, work, quantity of heat	joule	J	N·m
Power, radiant flux	watt	W	J/s
Quantity of electricity, electric charge	coulomb	C	A·s
Electric potential, potential difference, electromotive force	volt	V	W/A
Capacitance	farad	F	C/V
Electric resistance	ohm	Ω	V/A
Conductance	siemens	S	A/V
Magnetic flux	weber	Wb	V·s
Magnetic flux density	tesla	T	Wb/m^2
Inductance	henry	H	Wb/A
Luminous flux	lumen	lm	cd·sr
Illuminance	lux	lx	lm/m^2
Activity (of radionuclides)	becquerel	Bq	1/s
Absorbed dose	gray	Gy	J/kg

CONVERSION FACTORS

To convert	to	multiply by
LENGTH		
1 mile (U.S. statute)	km	1.609 347
1 yd	m	0.9144
1 ft	m	0.3048
	mm	304.8
1 in	mm	25.4
AREA		
1 mile^2 (U.S. statute)	km^2	2.589 99
1 acre (U.S. survey)	ha	0.404 687
	m^2	4046.87
1 yd^2	m^2	0.836 127
1 ft^2	m^2	0.092 903
1 in^2	mm^2	645.16
VOLUME, MODULUS OF SECTION		
1 acre ft	m^3	1233.49
1 yd^3	m^3	0.764 555
100 board ft	m^3	0.235 974
1 ft^3	m^3	0.028 316 8
	L (dm^3)	28.3168
1 in^3	mm^3	16 387.1
	mL (cm^3)	16.3871
1 barrel (42 U.S. gallons)	m^3	.158 987

(Continued)

CONVERSION FACTORS—(Continued)

To convert	to	multiply by
(FLUID) CAPACITY		
1 gal (U.S. liquid)**	L*	3.785 41
1 qt (U.S. liquid)	mL	946.353
1 pt (U.S. liquid)	mL	473.177
1 fl oz (U.S.)	mL	29.5735
1 gal (U.S. liquid)	m^3	0.003 785
**1 gallon (UK) approx. 1.2 gal (U.S.) *1 liter approx. 0.001 cubic meters		
SECOND MOMENT OF AREA		
1 in^4	mm^4	416 231
	m^4	$0.416\ 231 \times 10^{-6}$
PLANE ANGLE		
1° (degree)	rad	0.017 453 3
	mrad	17.4533
1′ (minute)	urad	290.888
1″ (second)	urad	4.848 14
VELOCITY, SPEED		
1 ft/s	m/s	0.3048
1 mile/h	km/h	1.609 344
	m/s	0.447 04
VOLUME RATE OF FLOW		
1 ft^3/s	m^3/s	0.028 316 8
1 ft^3/min	L/s	0.471 947
1 gal/min	L/s	0.063 090 2
1 gal/min	m^3/min	0.0038
1 gal/h	mL/s	1.051 50
1 million gal/d	L/s	43.8126
1 acre ft/s	m^3/s	1233.49
TEMPERATURE INTERVAL		
1°F	°C or K	0.555 556
		5/9°C = 5/9 K
EQUIVALENT TEMPERATURE ($t_{°C} = T_K - 273.15$)		
$t_{°F}$		$9/5\ t_{°C} + 32$
MASS		
1 ton (short***)	metric ton	0.907 185
	kg	907.185
1 lb	kg	0.453 592
1 oz	g	28.3495
***1 long ton (2240 lb)	kg	1016.05
MASS PER UNIT AREA		
1 lb/ft^2	kg/m^2	4.882 43
1 oz/yd^2	g/m^2	33.9057
1 oz/ft^2	g/m^2	305.152

(Continued)

CONVERSION FACTORS—(Continued)

To convert	to	multiply by
DENSITY (MASS PER UNIT VOLUME)		
1 lb/ft^3	kg/m^3	16.0185
1 lb/yd^3	kg/m^3	0.593 276
1 ton/yd^3	t/m^3	1.186 55
FORCE		
1 tonf (ton-force)	kN	8.896 44
1 kip (1000 lbf)	kN	4.448 22
1 lbf (pound-force)	N	4.448 22
MOMENT OF FORCE, TORQUE		
1 lbf·ft	N·m	1.355 82
1 lbf·in	N·m	0.112 985
1 tonf·ft	kN·m	2.711 64
1 kip·ft	kN·m	1.355 82
FORCE PER UNIT LENGTH		
1 lbf/ft	N/m	14.5939
1 lbf/in	N/m	175.127
1 tonf/ft	kN/m	29.187 8
PRESSURE, STRESS, MODULUS OF ELASTICITY (FORCE PER UNIT AREA) (1 Pa = 1 N/m^2)		
1 tonf/in^2	MPa	13.7895
1 tonf/ft^2	kPa	95.7605
1 kip/in^2	MPa	6.894 76
1 lbf/in^2	kPa	6.894 76
1 lbf/ft^2	Pa	47.8803
Atmosphere	kPa	101.3250
1 inch mercury	kPa	3.376 85
1 foot (water column @32°F)	kPa	2.988 98
WORK, ENERGY, HEAT (1J = 1N·m = 1W·s)		
1 kWh (550 ft·lbf/s)	Mj	3.6
1 Btu (Int. Table)	kJ	1.055 06
	J	1055.06
1 ft·lbf	J	1.355 82
COEFFICIENT OF HEAT TRANSFER		
1 Btu/(ft^2·h·°F)	W/(m^2·K)	5.678 26
THERMAL CONDUCTIVITY		
1 Btu/(ft·h·°F)	W/(m·K)	1.730 73
ILLUMINANCE		
1 lm/ft^2 (footcandle)	lx (lux)	10.7639
LUMINANCE		
1 cd/ft^2	cd/m^2	10.7639
1 foot lambert	cd/m^2	3.426 26
1 lambert	kcd/m^2	3.183 01

APPROXIMATE MINIMUM THICKNESS (INCH) FOR CARBON SHEET STEEL CORRESPONDING TO MANUFACTURER'S STANDARD GAGE AND GALVANIZED SHEET GAGE NUMBERS

CARBON SHEET STEEL			GALVANIZED SHEET		
MANUFACTURER'S STANDARD GAGE NO.	DECIMAL AND NOMINAL THICKNESS EQUIVALENT (Inch)	RECOMMENDED MINIMUM THICKNESS EQUIVALENT* (Inch)	GALVANIZED SHEET GAGE NO.	DECIMAL AND NOMINAL THICKNESS EQUIVALENT (Inch)	RECOMMENDED MINIMUM THICKNESS EQUIVALENT* (Inch)
8	.1644	.156	8	.1681	.159
9	.1495	.142	9	.1532	.144
10	.1345	.127	10	.1382	.129
11	.1196	.112	11	.1233	.114
12	.1046	.097	12	.1084	.099
13	.0897	.083	13	.0934	.084
14	.0747	.068	14	.0785	.070
15	.0673	.062	15	.0710	.065
16	.0598	.055	16	.0635	.058
17	.0538	.050	17	.0575	.053
18	.0478	.044	18	.0516	.047
19	.0418	.038	19	.0456	.041
20	.0359	.033	20	.0396	.036
21	.0329	.030	21	.0366	.033
22	.0299	.027	22	.0336	.030
23	.0269	.024	23	.0306	.027
24	.0239	.021	24	.0276	.024
25	.0209	.018	25	.0247	.021
26	.0179	.016	26	.0217	.019
27	.0164	.014	27	.0202	.017
28	.0149	.013	28	.0187	.016
			29	.0172	.014
			30	.0157	.013

(Continued)

APPROXIMATE MINIMUM THICKNESS (INCH) FOR CARBON SHEET STEEL CORRESPONDING TO MANUFACTURER'S STANDARD GAGE AND GALVANIZED SHEET GAGE NUMBERS—(Continued)

*The thickness of the sheets set forth in the code correspond to the thickness shown under these columns. They are the approximate minimum thicknesses and are based on the following references:

Carbon Sheet Steel—Thickness .071 inch and over:
ASTM A-568-74, Table 3, Thickness Tolerances of Hot-Rolled Sheet (Carbon Steel).

Carbon Sheet Steel—Thickness less than .071 inch:
ASTM A-568-74, Table 23, Thickness Tolerances of Cold-Rolled Sheet (Carbon and High Strength Low Alloy).

Galvanized Sheet Steel—All thicknesses:
ASTM A-525-79, Table 4, Thickness Tolerances of Hot-Dip Galvanized Sheet.

Minimum thickness is the difference between the thickness equivalent of each gage and the maximum negative tolerance for the widest rolled width.

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